Mobile Nephelometer for Ambient $PM_{2.5}$ Monitoring

OPERATIONAL PROCEDURES

For use with the M903 Radiance Research Nephelometer and
Garmin GPSMAP 60Cx

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APPENDICES

APPENDIX A - Mobile GPS Receiver/Data Logger GL-50S User's Manual Version 1.5 San Jose Navigation Inc, 2006

APPENDIX B - Operation Procedures M903 Nephelometer ROM Version 2.37.20DE Radiance Research, Seattle, WA

PURPOSE

This document outlines the operational procedures for measuring ambient particulate matter ($PM_{2.5}$) concentrations with a Radiance Research M903 Nephelometer and a GARMIN GPSMAP 60Cx GPS unit, as developed by researchers at UVic's Spatial Sciences Research Lab.

In addition to basic operational instructions, this manual provides additional documentation on downloading data, as well as preparing downloaded data for input into a Geographical Information System (GIS).

Manuals for the GARMIN GPS and the Radiance Research M903 nephelometer are included for further reference in Appendices A and B.

For technical assistance regarding general operation of equipment please contact:

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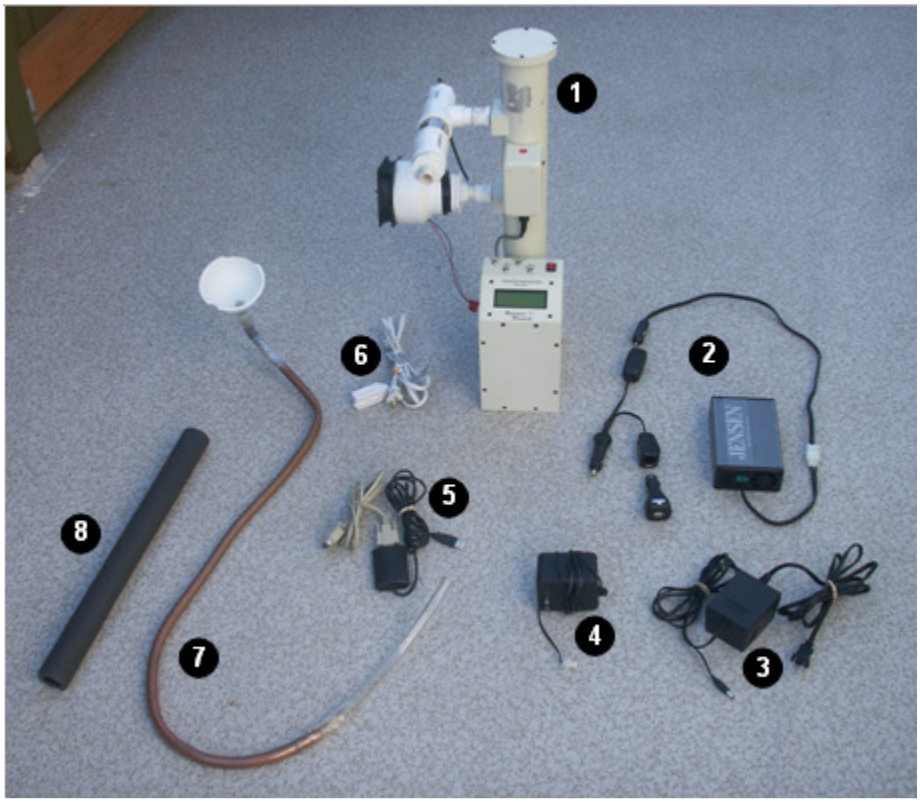
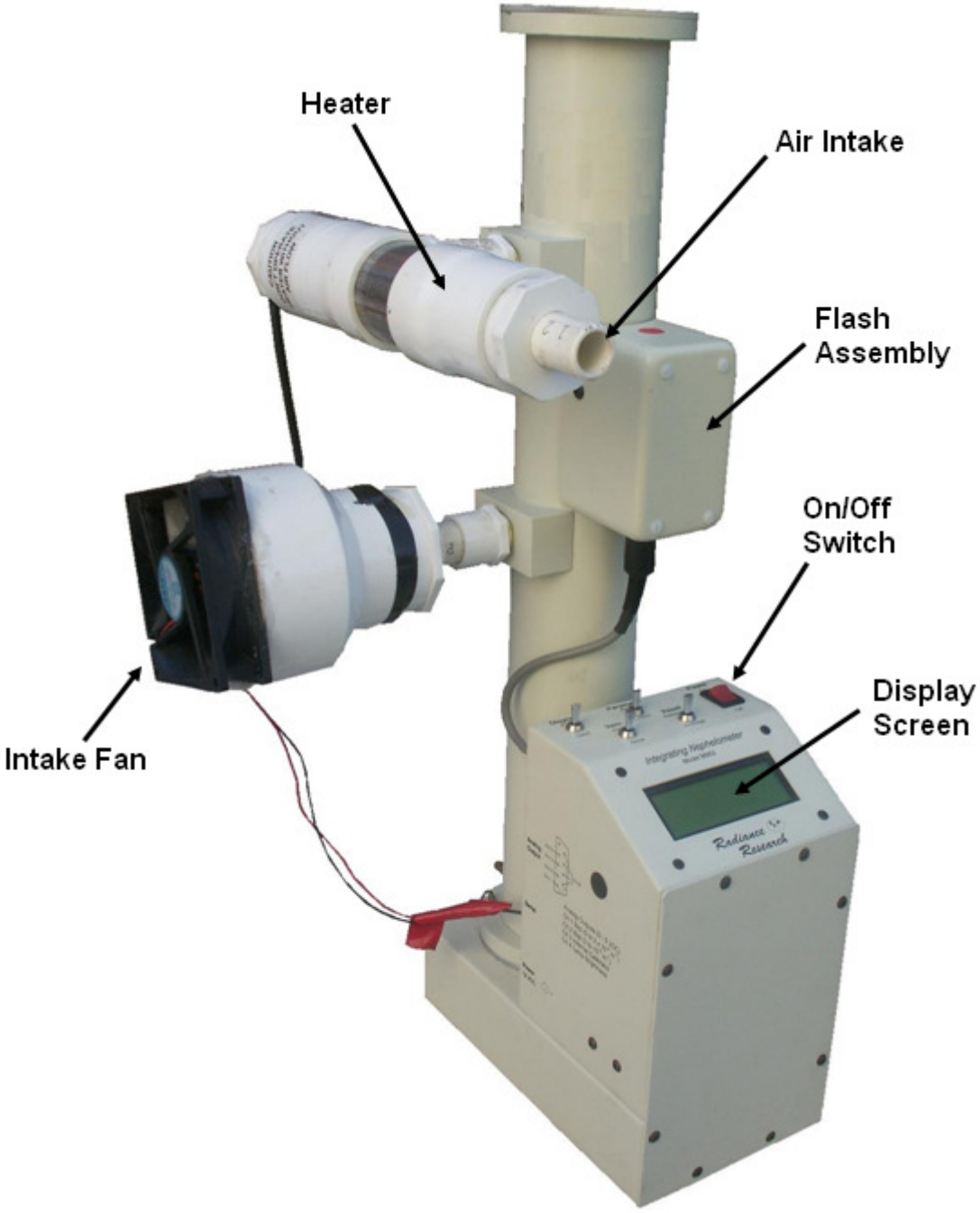
RADIANCE RESEARCH M903 NEPHELOMETER

Equipment Parts:

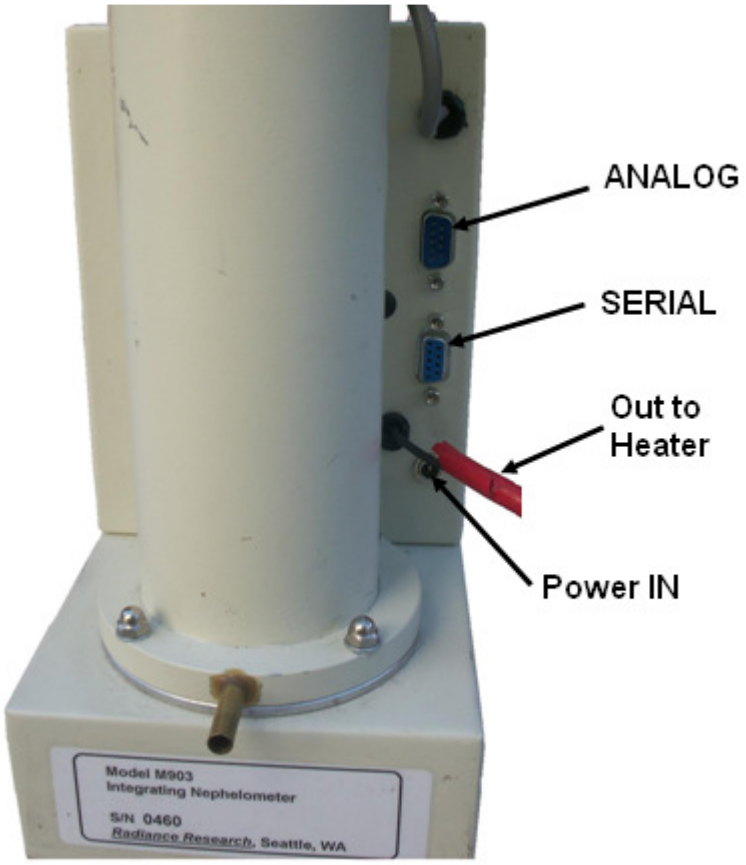


1. Nephelometer Unit
2. 12 Volt Inverter with adapter for car lighter/charger plug (may not look exactly like this)
3. Adaptor to Power Nephelometer Unit
4. Adaptor to Power Heater
5. Computer Connection Cables
6. Extension Cord
7. Copper Tubing with Funnel
8. Pipe Insulation Strip

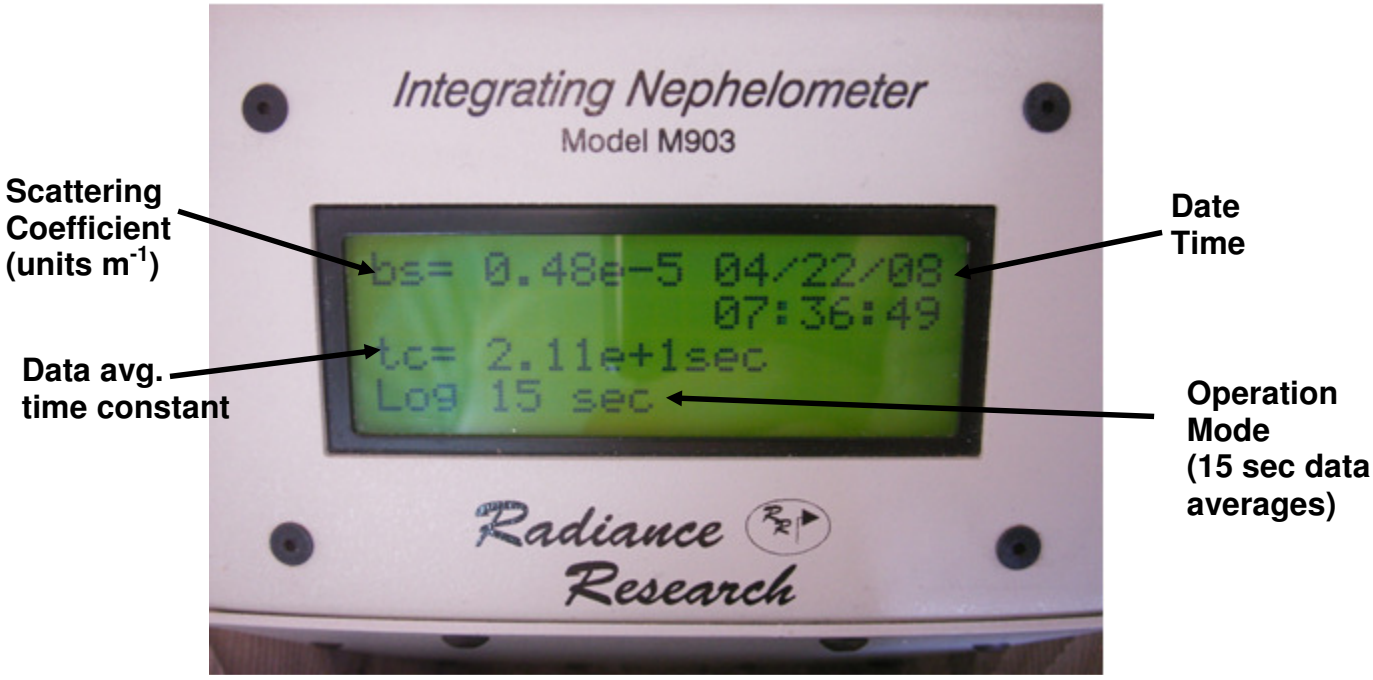
Nephelometer Unit:



Nephelometer Ports



Display Screen



GARMIN GPSMAP 60CX

Download Cable Not Shown

EQUIPMENT CHECKLIST

Make sure that the following equipment is on hand at the start of every data run:

Nephelometer:

- ☐ Large plastic Tupperware bin
- ☐ Small plastic bin
- ☐ Nephelometer unit
- ☐ Power adaptors (2)
- ☐ Copper tubing
- ☐ Funnel
- ☐ Pipe insulation strip
- ☐ Extension cord
- ☐ Inverter with lighter/charger adapter
- ☐ Data download cable
- ☐ Assorted software – SERIAL to USB cd and HYPERTERMINAL cd
- ☐ Bungee cords

GPS:

- ☐ GPS unit
- ☐ Extra AA batteries
- ☐ Download cable
- ☐ MapSource software cd

Other (Optional):

- ☐ Map and directions
- ☐ Duct tape
- ☐ Notepad and pen/pencil

VEHICLE SETUP (QUICK CHECK)

Setting up the GPS:

1. Turn on the GPS. Once signal is acquired, check it is in track mode (menu → tracks → Track Log on) and setup for 15 second logging.
2. Find a secure place on the dashboard.

Setting up the Nephelometer:

1. Connect the nephelometer to the power adaptor.
2. Connect the heater to the other power adaptor. (There is a special white connector on this one).
3. Plug both adaptors into extension cord. Secure with rubber bands if necessary.
4. Secure the nephelometer into the large plastic Tupperware bin using bungee cords to ensure it does not tip over. Place the adaptors alongside the nephelometer, letting the white extension cord hang out.
5. Place the nephelometer in the passenger or backseat.
6. Attach the copper tubing to the air intake attached to the heater.
7. Place the copper sample tube out the window. The funnel should be secured to the outside end using duct tape. Point the funnel down and slightly to the rear of the vehicle. Use the pipe insulation to keep cold air out of the vehicle.

Connecting to Power:

1. Make sure the inverter and all the connectors are properly attached.
2. Plug the extension cord from the nephelometer into the 12 volt inverter.
3. Plug the inverter into the lighter socket of the vehicle.
4. Start the vehicle.
5. Turn on the inverter, and then switch on the nephelometer. Check to make sure that the nephelometer is "ticking" and that the fan is running. Check all connections to the intake tube. Use duct tape as required.
6. When finished driving the route, turn off the nephelometer and GPS. Turn off the inverter and the car engine.

These directions are repeated on the following pages including reference pictures. Please refer to pages 7 to 16 for clarification of any of the instructions above.

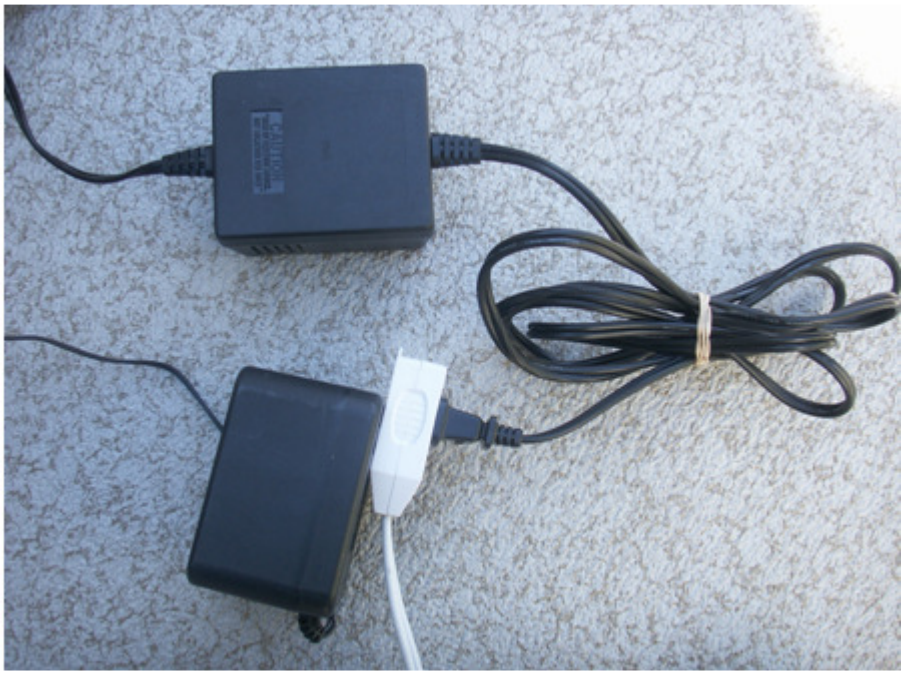
Vehicle Setup (COMPREHENSIVE)

Setting up the Nephelometer:

1. Connect the nephelometer to the power adaptor.

2. Connect the heater to the other power adaptor. There is a special white connector on this one:

Plug both adaptors into the extension cord. Secure with rubber bands if necessary.



3. Secure the nephelometer into the large plastic Tupperware bin using bungee cords to ensure it does not tip over. Place the adaptors alongside the nephelometer, letting the white extension cord hang out.

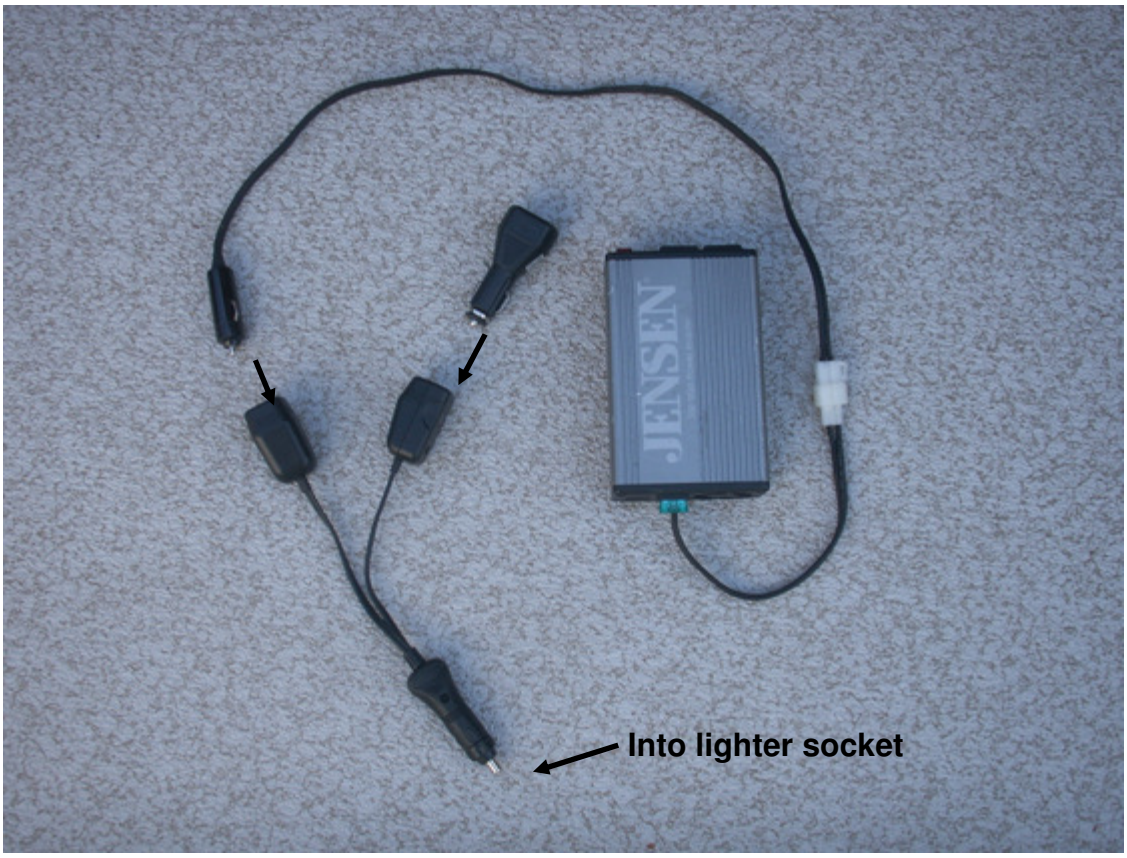
4. Place the nephelometer in the passenger or backseat.

5. Attach the copper tubing to the air intake attached to the heater.

6. Place the copper sample tube out the window. The funnel should be secured to the outside end using duct tape. Point the funnel down and slightly to the rear of the vehicle. Use the pipe insulation to keep cold air out of the vehicle.

Connecting to Power

1. Make sure the inverter and all the connectors are properly attached (see below, note may not look exactly the same):



2. Plug the extension cord from the nephelometer into the 12 volt inverter.

3. Plug the inverter into the lighter socket of the vehicle.

4. Start the vehicle.

5. Turn on the inverter, and then switch on the nephelometer. Check to make sure that the nephelometer is "ticking" and that the fan is running. Check all connections to the intake tube. Use duct tape as required.

6. When finished driving the route, turn off the nephelometer and GPS. Turn off the inverter and the car engine.

DOWNLOADING THE DATA

Before downloading any data from the GPS Unit or the Nephelometer, first **create a folder** on your computer where you will store your data. Always storing the data in a designated folder makes it easier to find later, and ensures that data remain organized.

GPS Data

Connect the GPS unit to the computer with the USB cable and turn on GPS.

1. Double click the MapSource icon on your computer.
2. Go to the Tracks tab and delete any existing tracks.
3. Click on Transfer → Receive from device. A new window will open, and should quickly find the GPS device. Click on Tracks in the What to Receive box, then click Receive. A new window should open with the message "transfer complete". Click OK.
4. You may see a number of ACTIVE LOG files. When you start out, the firsdt ACTIVE LOG is created. If the GPS looses signal, it closes the first LOG, and when signal is reacquired, a new ACTIVE LOG file is started.
5. To export the LOG files to a single text file, click on File→ Save As. A new window opens, allowing you to choose a save location, a new file name (i.e., GPS_date) and file type (use .txt).

Once you have successfully saved the text file – open it up (use Notepad or Excel) and check that the data are as expected. Then:

6. Close the MapSource software, do not save any changes.
7. On the GPS, in the Tracks menu, select Clear (enter) and confirm Yes.

NOTE – when there is no satellite signal, the Track Log will automatically be OFF.

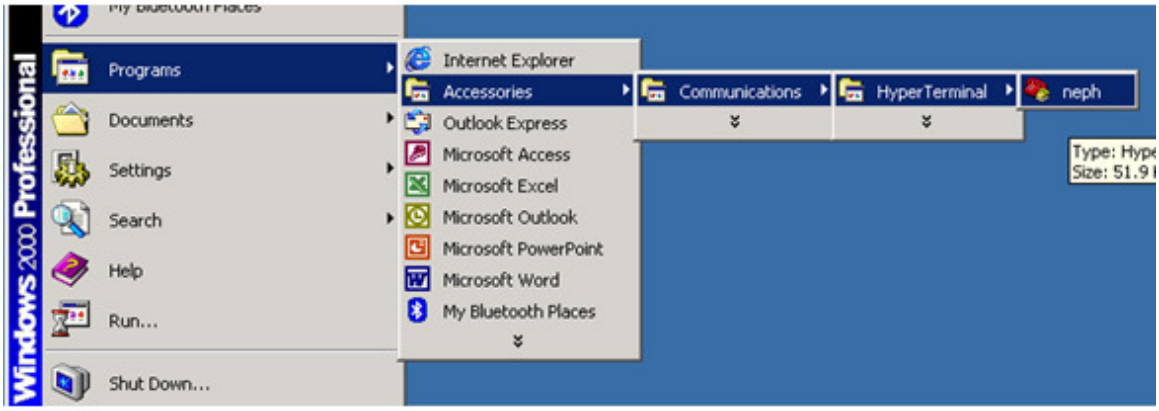
You will send the GPS_date.txt file to your GIS technician.

Nephelometer Data

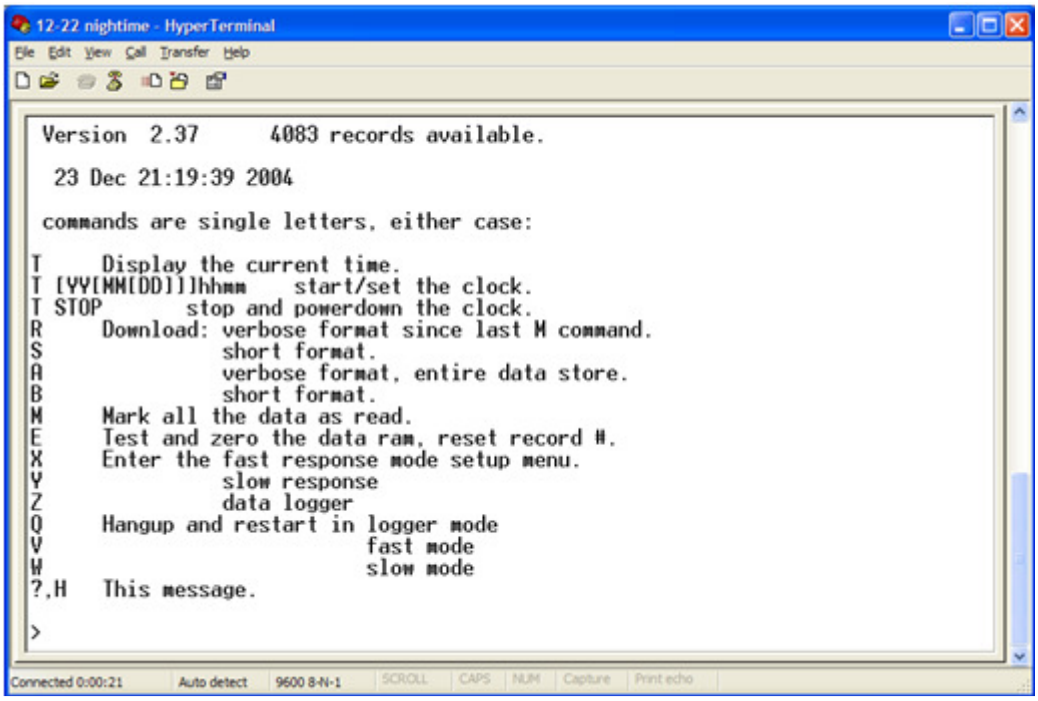
1. Connect the nephelometer to an external power source (do not turn on). Do not plug in the heater!

2. Connect the download cable to the USB Port.

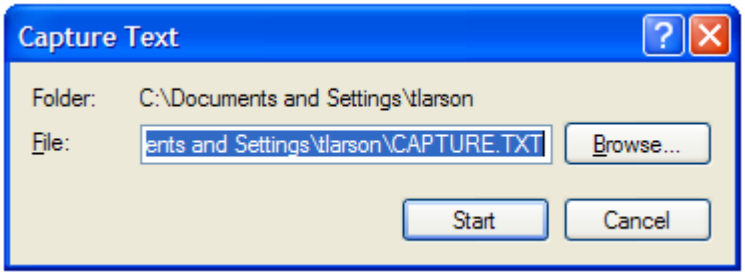
3. Open the saved nephelometer setting in the **Hyper Terminal** program (Programs/Accessories/Communications/Hyper Terminal/neph), or double click the Hyper Terminal icon on your desktop and use File → Open to select the neph.ht file.



4. A blank screen will appear. Now turn on the nephelometer. Data will begin scrolling down the screen. Hit the "s" key once and the main menu will appear, as shown:


12-22 nightime - HyperTerminal
File Edit View Call Transfer Help
Version 2.37 4083 records available.
23 Dec 21:19:39 2004
commands are single letters, either case:
T Display the current time.
T [YY[MM[DD]]]hhmm start/set the clock.
T STOP stop and powerdown the clock.
R Download: verbose format since last M command.
S short format.
A verbose format, entire data store.
B short format.
M Mark all the data as read.
E Test and zero the data ram, reset record #.
X Enter the fast response mode setup menu.
Y slow response
Z data logger
Q Hangup and restart in logger mode
V fast mode
W slow mode
?,H This message.
>
Connected 0:00:21
Auto detect
9600 8-N-1

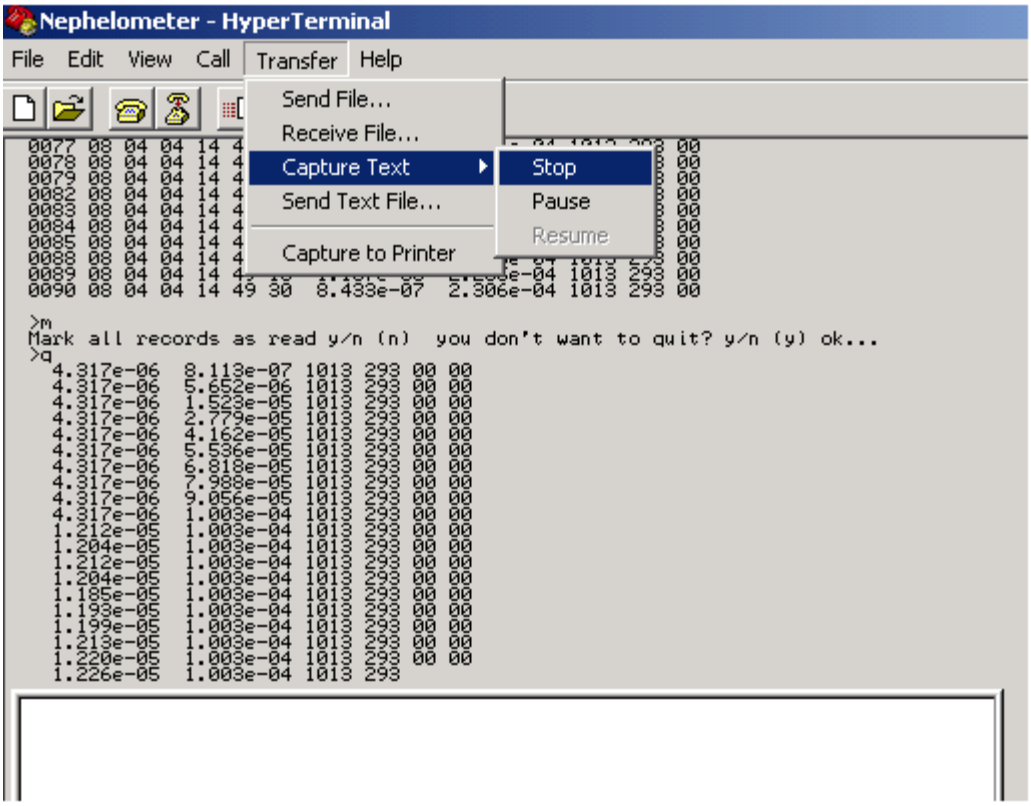
5. Select the "Transfer" menu in the Hyper Terminal menu bar. Then select "Capture Text to File". The program will ask you for a name (i.e., NEPH_Date.txt) and location of the text file that will be created. Select "Browse…" and choose a location to save the file.



6. Click "Start". The program will now store the information that subsequently appears on the screen as a text file in the location you specified.

7. Hit the "s" key once and then hit "enter". This will download all the 'unmarked' data in the nephelometer memory in short format. Data will begin scrolling down the screen. It will be saved to the text file you created.

8. When it has finished downloading select the "Transfer" menu in the Hyper Terminal menu bar and select Capture text > Stop.



9. Type "?" and hit return. This menu will appear again.

10. Type "M" to mark all the data as read and then hit "enter". When you do this, you will be prompted twice. Answer "y" to the first prompt (mark all records as read y/n), and "n" to the next prompt (you don't want to quit? y/n). The data are now marked at this point.

11. Type "Q" and then hit "enter". The nephelometer will now go into data-logging mode again. You should hear it ticking. You can now turn the nephelometer OFF. When it is turned on again it will automatically begin logging data.

12. Close the Hyper Terminal program. At the prompt, you can choose to save or not save the session file. The text file you created has already been automatically saved in the location you specified, so it is not necessary to save it again.

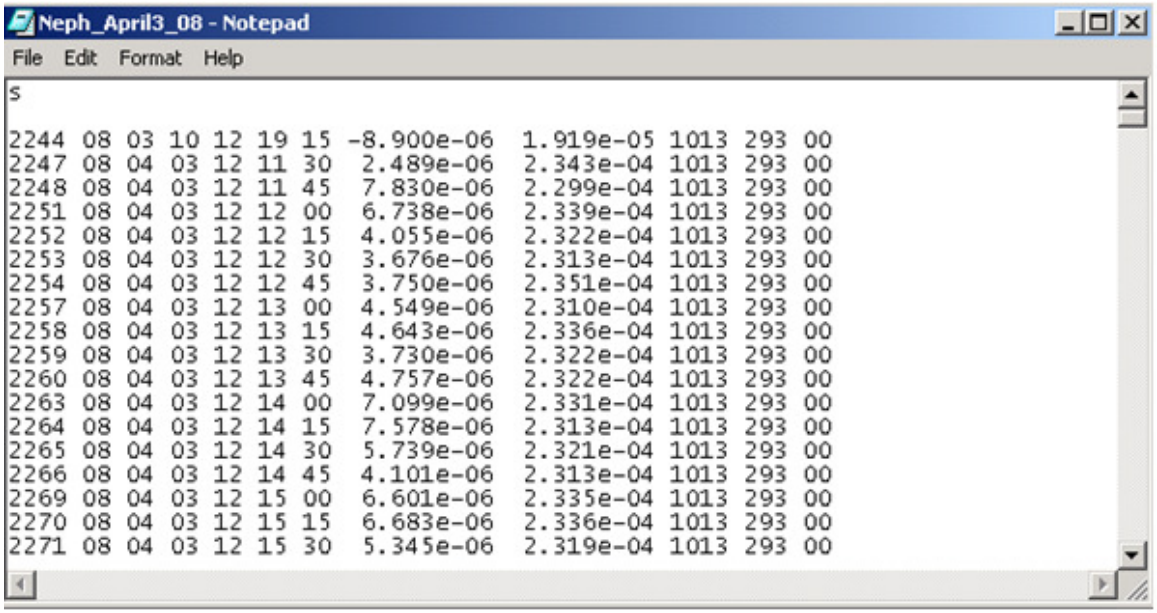
As a check, open the text file you just saved your data to, to make sure that the data did indeed download. If not, you may have to try downloading it again. Use Notepad or WordPad to open the .txt file. An example of what it should look like is provided on page 25 of the manual.

The NEPH_Date.txt file can now be sent on to a GIS technician for further analysis.

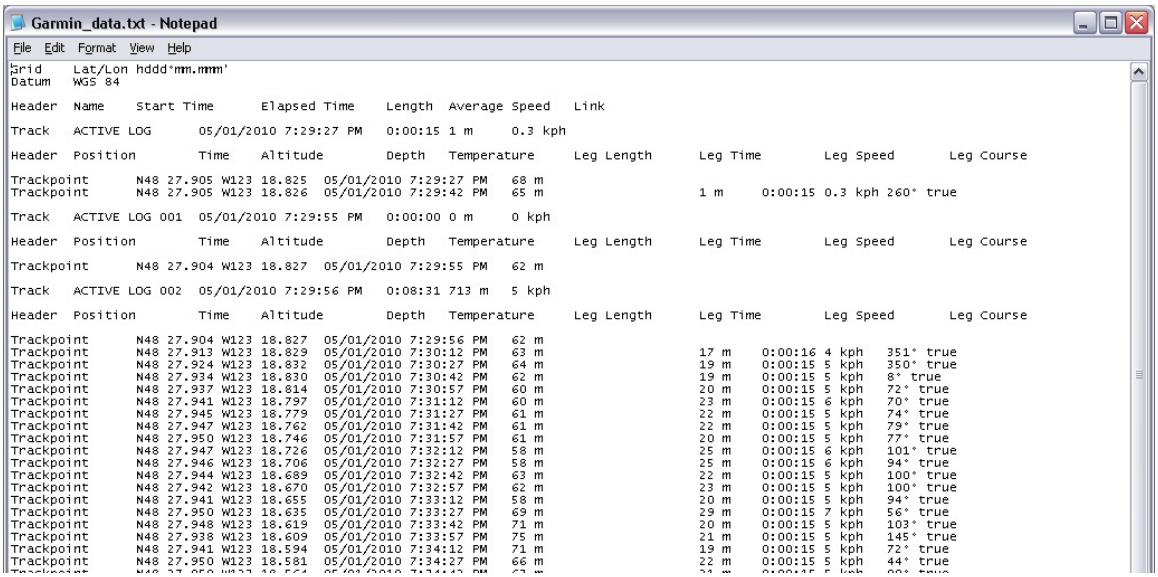
DATA FORMATTING

The text files which were created in the last section will look like the pictures below once you open them. Clearly, they require some formatting and explanation in order to be useable. This section will describe how to open and manipulate the files in Excel to prepare them for use in a Geographic Information System (GIS).

Nephelometer Data



GPS Data



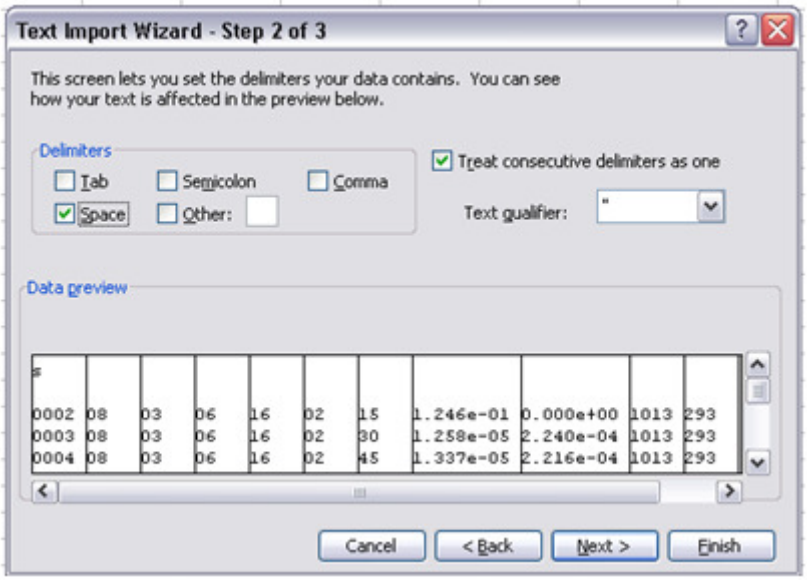
Preparing the Nephelometer Data

1. Open the NEPH_Date.txt file using Excel. To do this, first start Excel, then select File>Open. Find the nephelometer text file you saved. The Text Import Wizard opens.

In the first screen, choose **Delimited**, click next.

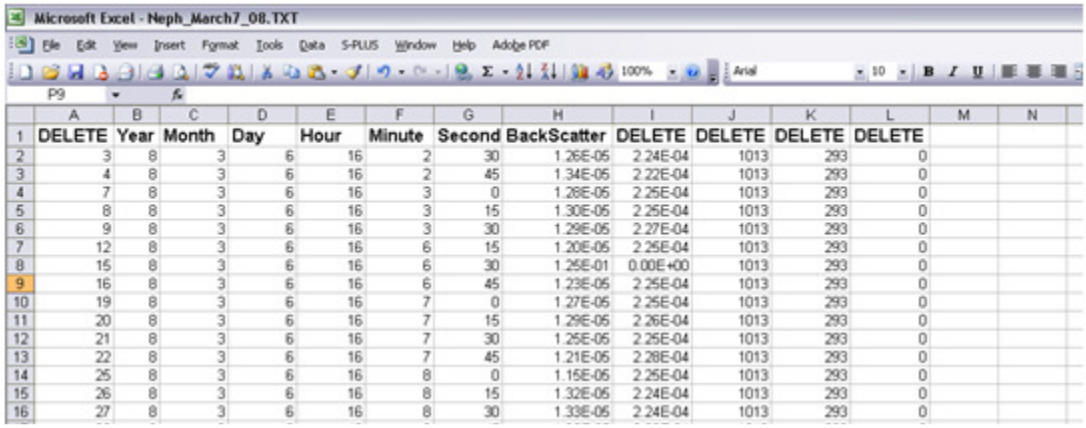
Text Import Wizard - Step 1 of 3
The Text Wizard has determined that your data is Fixed Width.
If this is correct, choose Next, or choose the data type that best describes your data.
Original data type
Choose the file type that best describes your data:
Delimited - Characters such as commas or tabs separate each field.
Fixed width - Fields are aligned in columns with spaces between each field.
Start import at row: 1
File origin: 437 : OEM United States
Preview of file F:\Neph_March7_08.TXT.
1 s
2
3 0002 08 03 06 16 02 15 1.246e-01 0.000e+00 1013 293 00
4 0003 08 03 06 16 02 30 1.258e-05 2.240e-04 1013 293 00
5 0004 08 03 06 16 02 45 1.337e-05 2.216e-04 1013 293 00
Cancel
< Back
Next >
Finish

In the second screen, choose **Space**, click finish.


Text Import Wizard - Step 2 of 3
This screen lets you set the delimiters your data contains. You can see how your text is affected in the preview below.
Delimiters
Tab
Semicolon
Comma
Space
Other:
Treat consecutive delimiters as one
Text qualifier:
Data preview
s
0002 08 03 06 16 02 15 1.246e-01 0.000e+00 1013 293
0003 08 03 06 16 02 30 1.258e-05 2.240e-04 1013 293
0004 08 03 06 16 02 45 1.337e-05 2.216e-04 1013 293
Cancel
< Back
Next >
Finish

There may be a few rows of general text that can be deleted, and often the first several rows of nephelometer data should be deleted, as these were captured right when the nephelometer was turned on and may not be accurate.

2. Delete the first column, and the last four columns (see figure below – delete columns shown as DELETE). Do this by right-clicking the letter above the column you want to delete and selecting "delete" from the menu that appears. Insert a row at the top and add headings to the remaining columns, as displayed in the image below. Do this by right-clicking the number of the row (in the far left of the window) you would like the new row inserted above and selecting "insert" from the menu that appears.

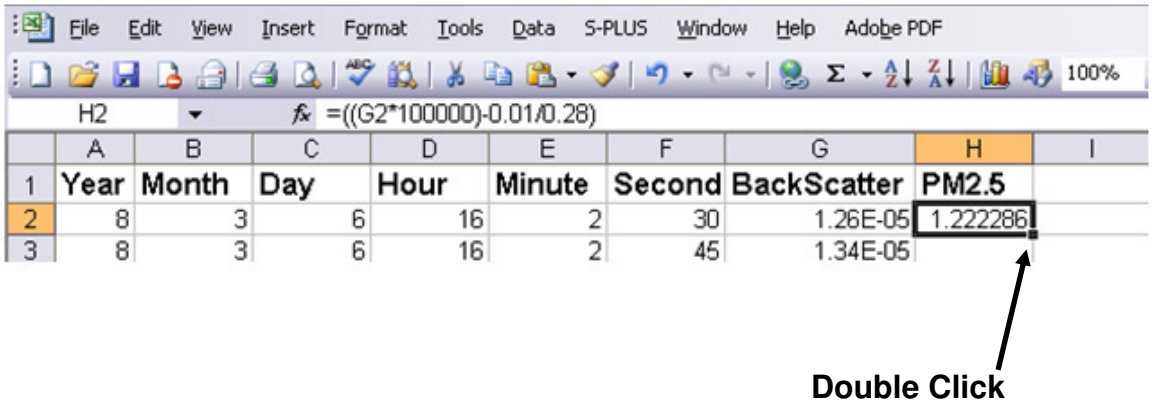


	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	DELETE	Year	Month	Day	Hour	Minute	Second	BackScatter	DELETE	DELETE	DELETE	DELETE		
2	3	8	3	6	16	2	30	1.26E-05	2.24E-04	1013	293	0		
3	4	8	3	6	16	2	45	1.34E-05	2.22E-04	1013	293	0		
4	7	8	3	6	16	3	0	1.28E-05	2.25E-04	1013	293	0		
5	8	8	3	6	16	3	15	1.30E-05	2.25E-04	1013	293	0		
6	9	8	3	6	16	3	30	1.29E-05	2.27E-04	1013	293	0		
7	12	8	3	6	16	6	15	1.20E-05	2.25E-04	1013	293	0		
8	15	8	3	6	16	6	30	1.25E-01	0.00E+00	1013	293	0		
9	16	8	3	6	16	6	45	1.23E-05	2.25E-04	1013	293	0		
10	19	8	3	6	16	7	0	1.27E-05	2.25E-04	1013	293	0		
11	20	8	3	6	16	7	15	1.29E-05	2.26E-04	1013	293	0		
12	21	8	3	6	16	7	30	1.25E-05	2.25E-04	1013	293	0		
13	22	8	3	6	16	7	45	1.21E-05	2.28E-04	1013	293	0		
14	25	8	3	6	16	8	0	1.15E-05	2.25E-04	1013	293	0		
15	26	8	3	6	16	8	15	1.32E-05	2.24E-04	1013	293	0		
16	27	8	3	6	16	8	30	1.33E-05	2.24E-04	1013	293	0		

3. Convert the BackScatter to PM_25: add the heading in the right-most column, add the following equation:

=((G2*100000)-0.01)/0.28

to the first cell in the PM_25 column, then double-click the lower right corner of the cell. This should automatically put the equation in the remaining cells in the column.

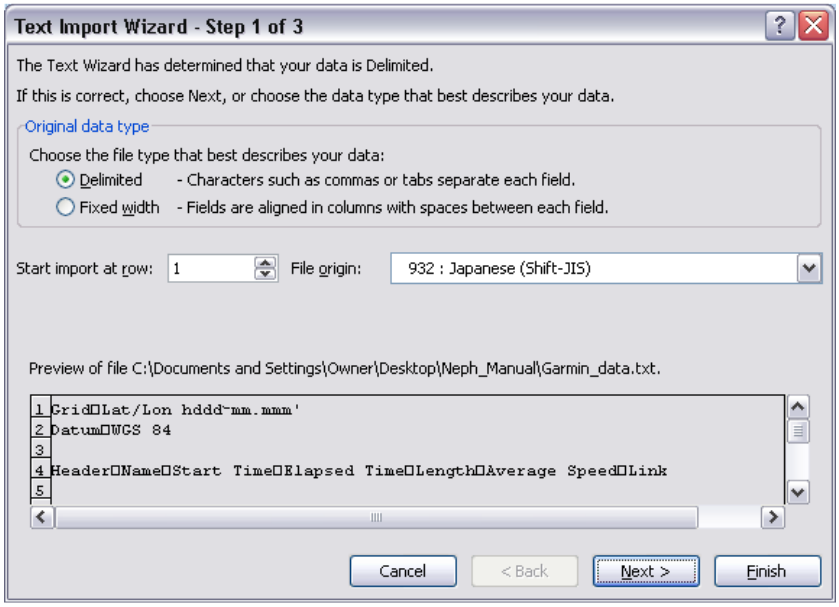


	A	B	C	D	E	F	G	H	I
1	Year	Month	Day	Hour	Minute	Second	BackScatter	PM2.5	
2	8	3	6	16	2	30	1.26E-05	1.222286	
3	8	3	6	16	2	45	1.34E-05		

4. Save the spreadsheet as *NewName.xls* and minimize.

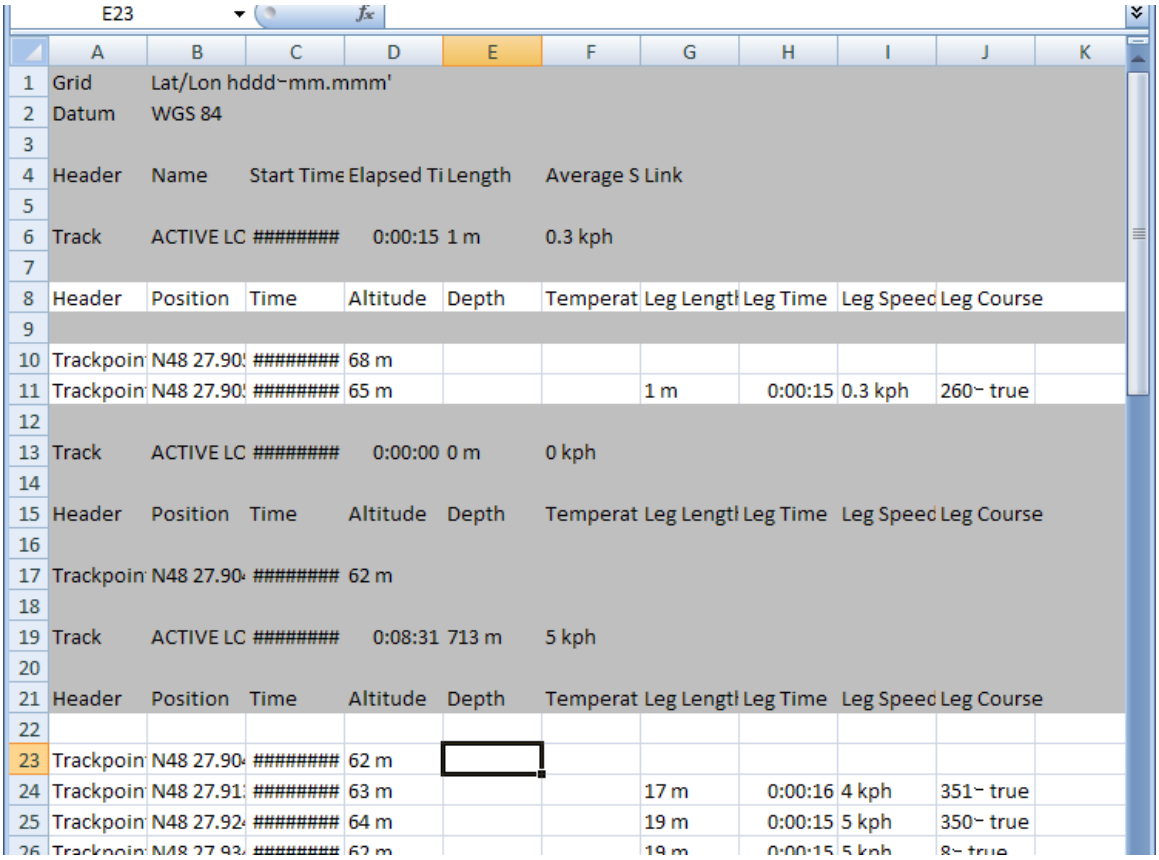
Preparing the GPS Data

1. In Excel, open the GPS_Date.txt file. The Text Import Wizard opens. In the first screen, choose **delimited**, and click finish. Before doing any re-formatting, save this file with a new name (i.e., GPS_Date_formatted.txt).


Text Import Wizard - Step 1 of 3
The Text Wizard has determined that your data is Delimited.
If this is correct, choose Next, or choose the data type that best describes your data.
Original data type
Choose the file type that best describes your data:
Delimited - Characters such as commas or tabs separate each field.
Fixed width - Fields are aligned in columns with spaces between each field.
Start import at row: 1
File origin: 932 : Japanese (Shift-JIS)
Preview of file C:\Documents and Settings\Owner\Desktop\Neph_Manual\Garmin_data.txt.
1 Grid□Lat/Lon hddd~mm.mmm'
2 Datum□WGS 84
3
4 Header□Name□Start Time□Elapsed Time□Length□Average Speed□Link
5
Cancel
< Back
Next >
Finish

	A	B	C	D	E	F	G	H	I	J	K
1	Grid	Lat/Lon hddd~mm.mmm'									
2	Datum	WGS 84									
3											
4	Header	Name	Start Time	Elapsed Ti	Length	Average S	Link				
5											
6	Track	ACTIVE LC	########	0:00:15	1 m	0.3 kph					
7											
8	Header	Position	Time	Altitude	Depth	Temperat	Leg Lengtl	Leg Time	Leg Speed	Leg Course	
9											
10	Trackpoin	N48 27.90	########	68 m							
11	Trackpoin	N48 27.90	########	65 m			1 m	0:00:15	0.3 kph	260~ true	
12											
13	Track	ACTIVE LC	########	0:00:00	0 m	0 kph					
14											
15	Header	Position	Time	Altitude	Depth	Temperat	Leg Lengtl	Leg Time	Leg Speed	Leg Course	
16											
17	Trackpoin	N48 27.90	########	62 m							
18											
19	Track	ACTIVE LC	########	0:08:31	713 m	5 kph					
20											
21	Header	Position	Time	Altitude	Depth	Temperat	Leg Lengtl	Leg Time	Leg Speed	Leg Course	
22											
23	Trackpoin	N48 27.90	########	62 m							
24	Trackpoin	N48 27.91	########	63 m			17 m	0:00:16	4 kph	351~ true	
25	Trackpoin	N48 27.92	########	64 m			19 m	0:00:15	5 kph	350~ true	
26	Trackpoin	N48 27.93	########	62 m			19 m	0:00:15	5 kph	8~ true	
27	Trackpoin	N48 27.93	########	60 m			20 m	0:00:15	5 kph	72~ true	
28	Trackpoin	N48 27.94	########	60 m			23 m	0:00:15	6 kph	70~ true	

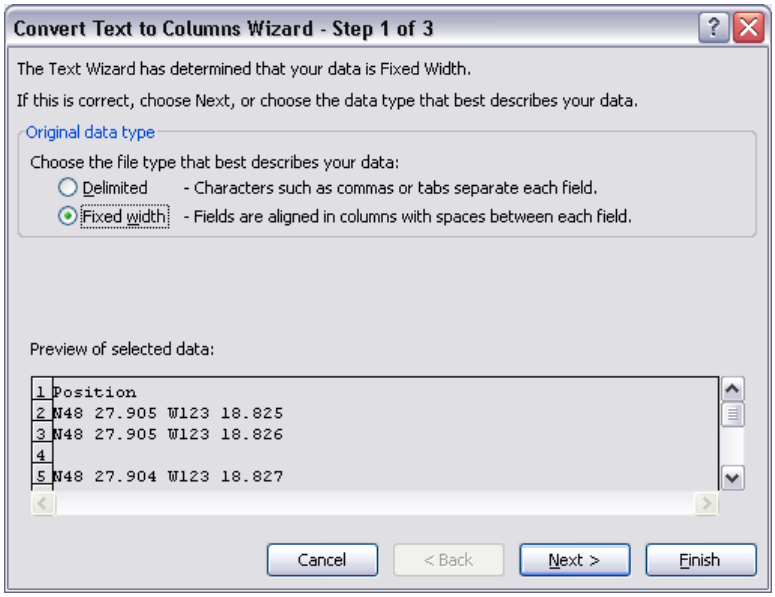
2. Remember, you may have a number of ACTIVE LOG files, if you lost GPS signal at any point. Each ACTIVE LOG file will be listed in the spreadsheet. You only need to keep the rows that start with "Trackpoint" and the Header row above the first Trackpoint row (rows to delete are colored grey in the figure below). Keep an empty row between the data for each ACTIVE LOG file, as this will help you to find time gaps later when you are matching the GPS data to the nephelometer data.



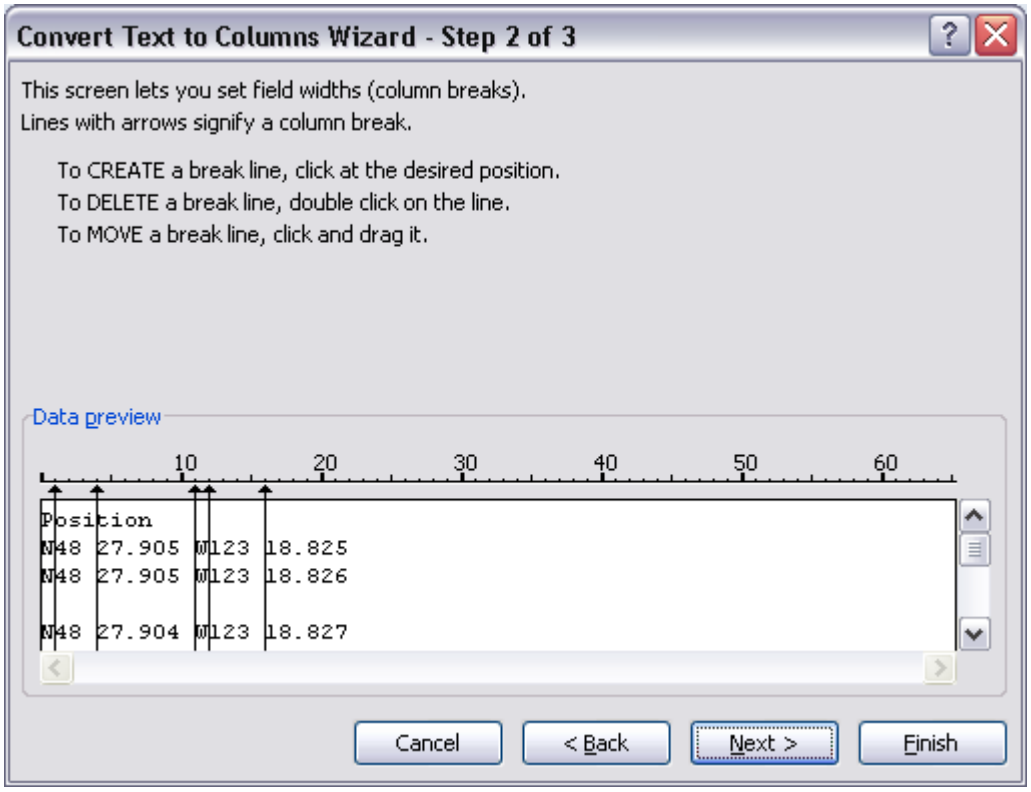
	A	B	C	D	E	F	G	H	I	J	K
1	Grid	Lat/Lon hddd-mm.mmm'									
2	Datum	WGS 84									
3											
4	Header	Name	Start Time	Elapsed Ti	Length	Average S	Link				
5											
6	Track	ACTIVE LC	########	0:00:15	1 m	0.3 kph					
7											
8	Header	Position	Time	Altitude	Depth	Temperat	Leg Length	Leg Time	Leg Speed	Leg Course	
9											
10	Trackpoin	N48 27.90	########	68 m							
11	Trackpoin	N48 27.90	########	65 m			1 m	0:00:15	0.3 kph	260° true	
12											
13	Track	ACTIVE LC	########	0:00:00	0 m	0 kph					
14											
15	Header	Position	Time	Altitude	Depth	Temperat	Leg Length	Leg Time	Leg Speed	Leg Course	
16											
17	Trackpoin	N48 27.90	########	62 m							
18											
19	Track	ACTIVE LC	########	0:08:31	713 m	5 kph					
20											
21	Header	Position	Time	Altitude	Depth	Temperat	Leg Length	Leg Time	Leg Speed	Leg Course	
22											
23	Trackpoin	N48 27.90	########	62 m							
24	Trackpoin	N48 27.91	########	63 m			17 m	0:00:16	4 kph	351° true	
25	Trackpoin	N48 27.92	########	64 m			19 m	0:00:15	5 kph	350° true	
26	Trackpoin	N48 27.93	########	62 m			19 m	0:00:15	5 kph	8° true	

3. Delete all but the Position and Time columns. Now, you'll need to reformat these two columns to end up with a Latitude, Longitude and Time that shows the seconds.

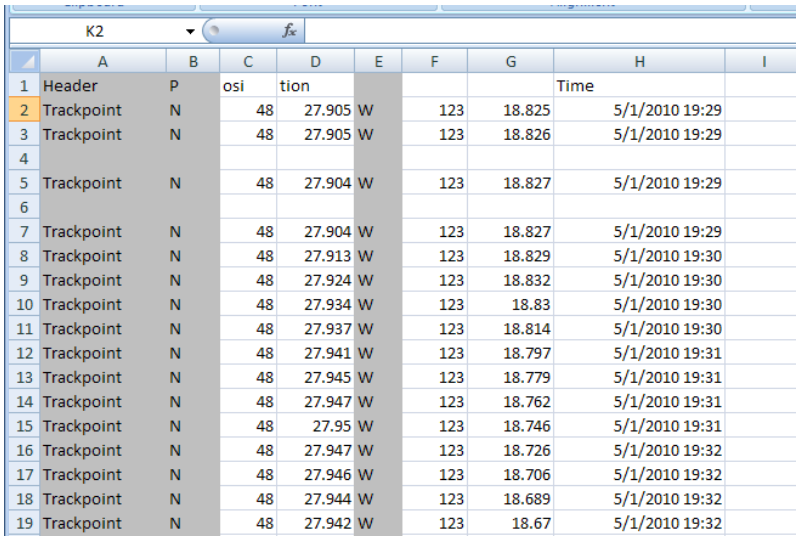
- Insert five new columns to the right of the Position column
- Select the Position column, and then the Data → Text to Columns tool. A new window will open. Choose fixed width and click on Next.


Convert Text to Columns Wizard - Step 1 of 3
The Text Wizard has determined that your data is Fixed Width.
If this is correct, choose Next, or choose the data type that best describes your data.
Original data type
Choose the file type that best describes your data:
Delimited - Characters such as commas or tabs separate each field.
Fixed width - Fields are aligned in columns with spaces between each field.
Preview of selected data:
1 Position
2 N48 27.905 W123 18.825
3 N48 27.905 W123 18.826
4
5 N48 27.904 W123 18.827
Cancel
< Back
Next >
Finish

- Add break lines as shown and click Finish:


Convert Text to Columns Wizard - Step 2 of 3
This screen lets you set field widths (column breaks).
Lines with arrows signify a column break.
To CREATE a break line, click at the desired position.
To DELETE a break line, double click on the line.
To MOVE a break line, click and drag it.
Data preview
10
20
30
40
50
60
Position
N48 27.905 W123 18.825
N48 27.905 W123 18.826
N48 27.904 W123 18.827
Cancel
< Back
Next >
Finish

- Delete unnecessary rows (shown in grey below):



	A	B	C	D	E	F	G	H	I
1	Header	P	osi	tion				Time	
2	Trackpoint	N	48	27.905	W	123	18.825	5/1/2010 19:29	
3	Trackpoint	N	48	27.905	W	123	18.826	5/1/2010 19:29	
4									
5	Trackpoint	N	48	27.904	W	123	18.827	5/1/2010 19:29	
6									
7	Trackpoint	N	48	27.904	W	123	18.827	5/1/2010 19:29	
8	Trackpoint	N	48	27.913	W	123	18.829	5/1/2010 19:30	
9	Trackpoint	N	48	27.924	W	123	18.832	5/1/2010 19:30	
10	Trackpoint	N	48	27.934	W	123	18.83	5/1/2010 19:30	
11	Trackpoint	N	48	27.937	W	123	18.814	5/1/2010 19:30	
12	Trackpoint	N	48	27.941	W	123	18.797	5/1/2010 19:31	
13	Trackpoint	N	48	27.945	W	123	18.779	5/1/2010 19:31	
14	Trackpoint	N	48	27.947	W	123	18.762	5/1/2010 19:31	
15	Trackpoint	N	48	27.95	W	123	18.746	5/1/2010 19:31	
16	Trackpoint	N	48	27.947	W	123	18.726	5/1/2010 19:32	
17	Trackpoint	N	48	27.946	W	123	18.706	5/1/2010 19:32	
18	Trackpoint	N	48	27.944	W	123	18.689	5/1/2010 19:32	
19	Trackpoint	N	48	27.942	W	123	18.67	5/1/2010 19:32	

- The first two columns contain the latitude coordinates – the first is the degrees, the second is minutes.seconds. These need to be combined into degrees.minutes (commonly called decimal degrees). Insert a new column (called Latitude) to the right of column B, and enter the following equation into cell C2:

  =A2+(B2/60)

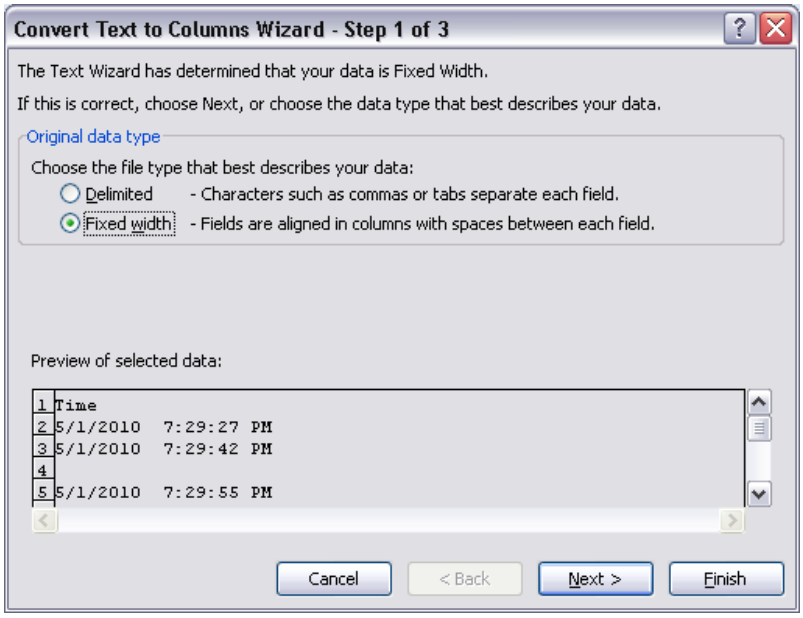
  Then, add a new column to the left of column E (called Longitude), and enter the following equation into cell F2:

  =D2+(E2/60))*-1

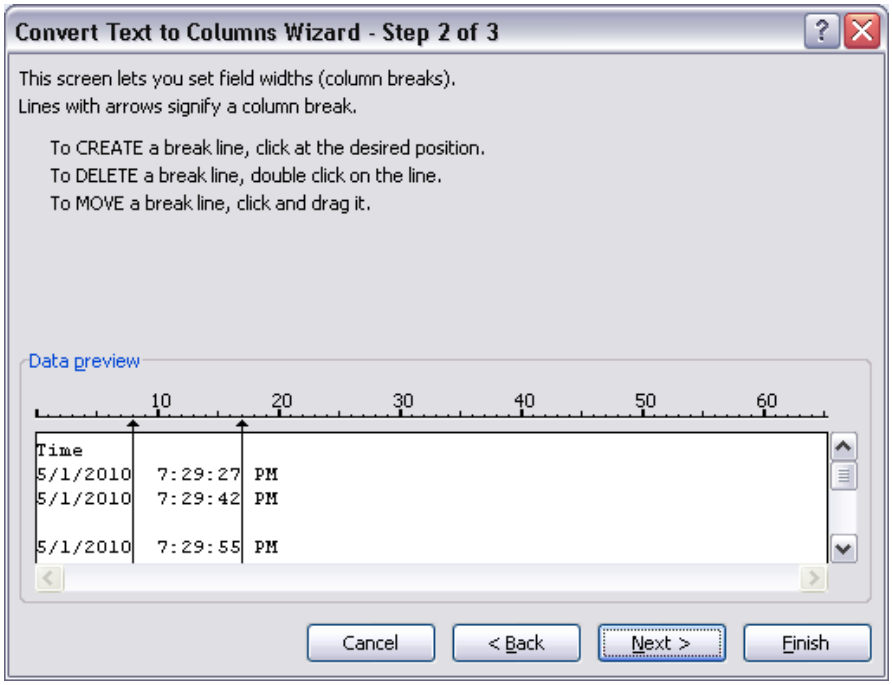
  Fill the remaining cells with these equations – highlight the first cell with the equation, go to the bottom of the column and shift-click on the last cell – this should select all the cells in the column, then hit ctrl-d – this will copy the equation all the way down.

  Copy and paste 'values', so when we delete columns A, B, D and E, the final values will remain in columns C and F – select the entire C column, then click ctrl-c to copy, and then paste→ paste special → values. Do the same for column F.

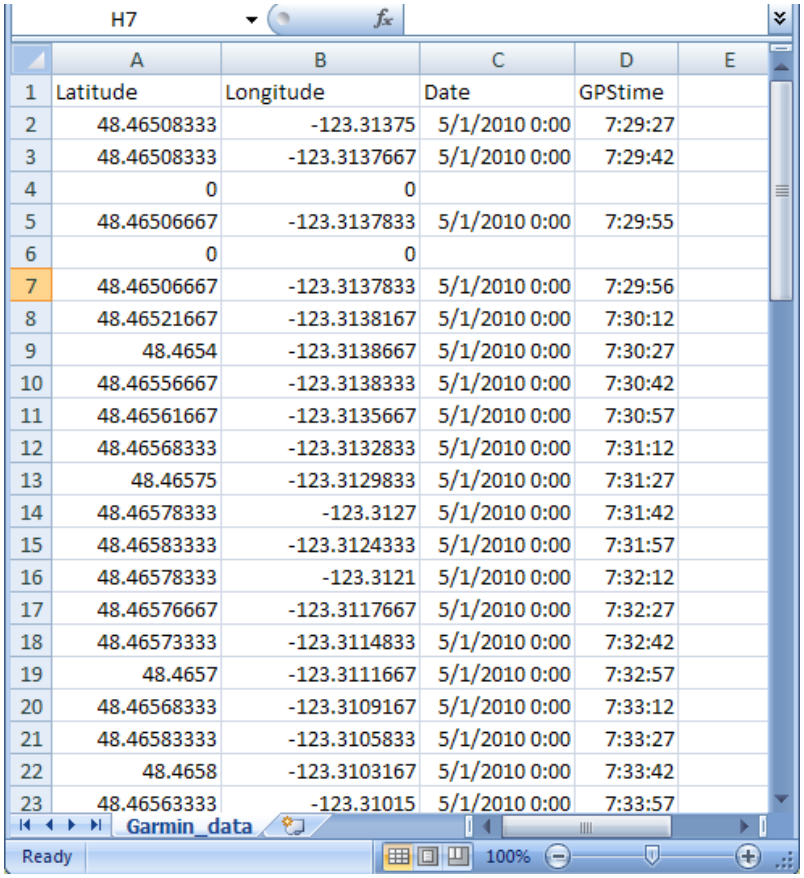
- Finally, use the text-to-columns tool to split the date and time. Highlight the Time column, click on data→ text to columns, and when the new window opens, select fixed width and click next


Convert Text to Columns Wizard - Step 1 of 3
The Text Wizard has determined that your data is Fixed Width.
If this is correct, choose Next, or choose the data type that best describes your data.
Original data type
Choose the file type that best describes your data:
Delimited - Characters such as commas or tabs separate each field.
Fixed width - Fields are aligned in columns with spaces between each field.
Preview of selected data:
1 Time
2 5/1/2010 7:29:27 PM
3 5/1/2010 7:29:42 PM
4
5 5/1/2010 7:29:55 PM
Cancel
< Back
Next >
Finish

- Add break lines as shown, and click finish.



- Rename the columns as appropriate, and save!!



H7

	A	B	C	D	E
1	Latitude	Longitude	Date	GPStime	
2	48.46508333	-123.31375	5/1/2010 0:00	7:29:27	
3	48.46508333	-123.3137667	5/1/2010 0:00	7:29:42	
4	0	0			
5	48.46506667	-123.3137833	5/1/2010 0:00	7:29:55	
6	0	0			
7	48.46506667	-123.3137833	5/1/2010 0:00	7:29:56	
8	48.46521667	-123.3138167	5/1/2010 0:00	7:30:12	
9	48.4654	-123.3138667	5/1/2010 0:00	7:30:27	
10	48.46556667	-123.3138333	5/1/2010 0:00	7:30:42	
11	48.46561667	-123.3135667	5/1/2010 0:00	7:30:57	
12	48.46568333	-123.3132833	5/1/2010 0:00	7:31:12	
13	48.46575	-123.3129833	5/1/2010 0:00	7:31:27	
14	48.46578333	-123.3127	5/1/2010 0:00	7:31:42	
15	48.46583333	-123.3124333	5/1/2010 0:00	7:31:57	
16	48.46578333	-123.3121	5/1/2010 0:00	7:32:12	
17	48.46576667	-123.3117667	5/1/2010 0:00	7:32:27	
18	48.46573333	-123.3114833	5/1/2010 0:00	7:32:42	
19	48.4657	-123.3111667	5/1/2010 0:00	7:32:57	
20	48.46568333	-123.3109167	5/1/2010 0:00	7:33:12	
21	48.46583333	-123.3105833	5/1/2010 0:00	7:33:27	
22	48.4658	-123.3103167	5/1/2010 0:00	7:33:42	
23	48.46563333	-123.31015	5/1/2010 0:00	7:33:57	

Garmin_data

Ready

100%

COMBINING THE NEPHELOMETER AND GPS DATA

1. Finally, we are ready to combine the nephelometer and GPS data. Find the first common time in the nephelometer file and in the GPS file

Nephelometer data:

Microsoft Excel - Neph_March7_08.xls

File Edit View Insert Format Tools Data S-PLUS Window Help Adobe PDF

F2 0

	A	B	C	D	E	F	G	H	I
1	Year	Month	Day	Hour	Minute	Second	BackScatter	PM2.5	
2	8	3	7	12	7	0	1.75E-05	1.713286	
3	8	3	7	12	7	15	1.86E-05	1.824286	
4	8	3	7	12	7	30	1.96E-05	1.923286	
5	8	3	7	12	7	45	1.94E-05	1.903286	
6	8	3	7	12	8	0	1.97E-05	1.929286	
7	8	3	7	12	8	45	1.38E-06	0.101886	
8	8	3	7	12	10	0	1.87E-05	1.831286	
9	8	3	7	12	10	15	2.02E-05	1.980286	
10	8	3	7	12	10	30	1.94E-05	1.900286	
11	8	3	7	12	10	45	2.08E-05	2.043286	

12:07:00 PM

GPS data
(note this may not look exactly
the same as your spreadsheet):

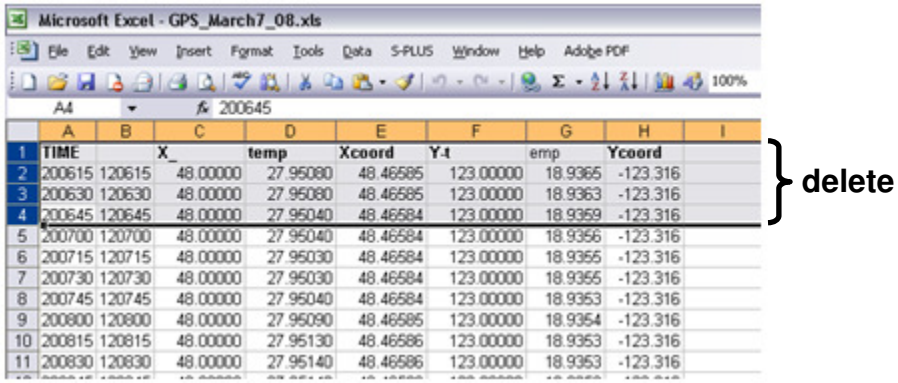
Microsoft Excel - GPS_March7_08.xls

File Edit View Insert Format Tools Data S-PLUS Window Help Adobe PDF

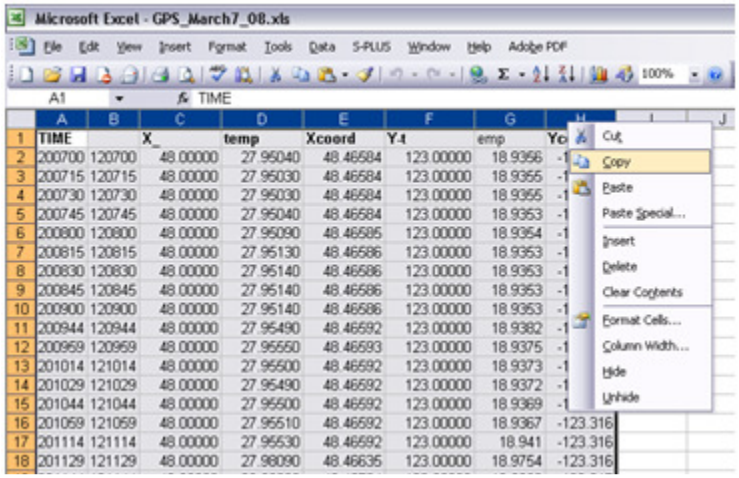
A5 200700

	A	B	C	D	E	F	G	H	I	J
1	TIME		X	temp	Xcoord	Y-t	emp	Ycoord		
2	200615	120615	48.00000	27.95080	48.46585	123.00000	18.9365	-123.316		
3	200630	120630	48.00000	27.95080	48.46585	123.00000	18.9363	-123.316		
4	200645	120645	48.00000	27.95040	48.46584	123.00000	18.9359	-123.316		
5	200700	120700	48.00000	27.95040	48.46584	123.00000	18.9356	-123.316		
6	200715	120715	48.00000	27.95030	48.46584	123.00000	18.9355	-123.316		
7	200730	120730	48.00000	27.95030	48.46584	123.00000	18.9355	-123.316		
8	200745	120745	48.00000	27.95040	48.46584	123.00000	18.9353	-123.316		
9	200800	120800	48.00000	27.95090	48.46585	123.00000	18.9354	-123.316		
10	200815	120815	48.00000	27.95130	48.46586	123.00000	18.9353	-123.316		
11	200830	120830	48.00000	27.95140	48.46586	123.00000	18.9353	-123.316		

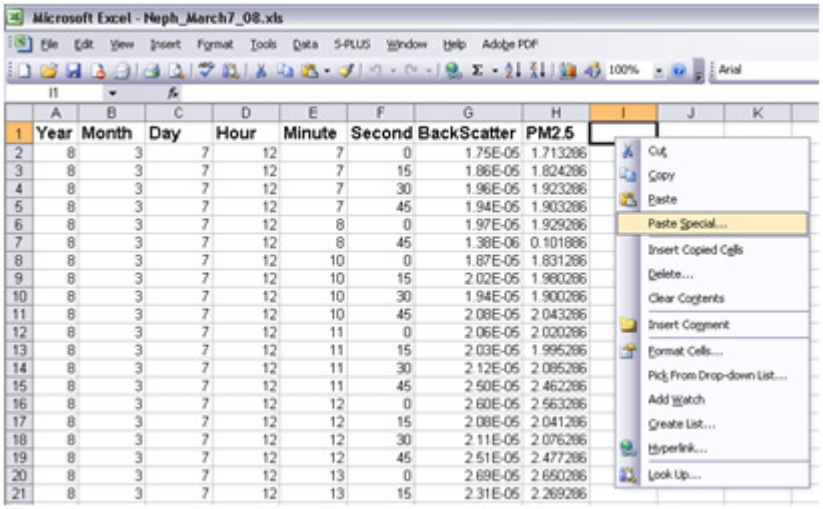
2. Delete the rows in the nephelometer or GPS file that do not match at the beginning. For example, you may have turned on the nephelometer before the GPS, or the GPS may have started logging before you turned on the nephelometer.



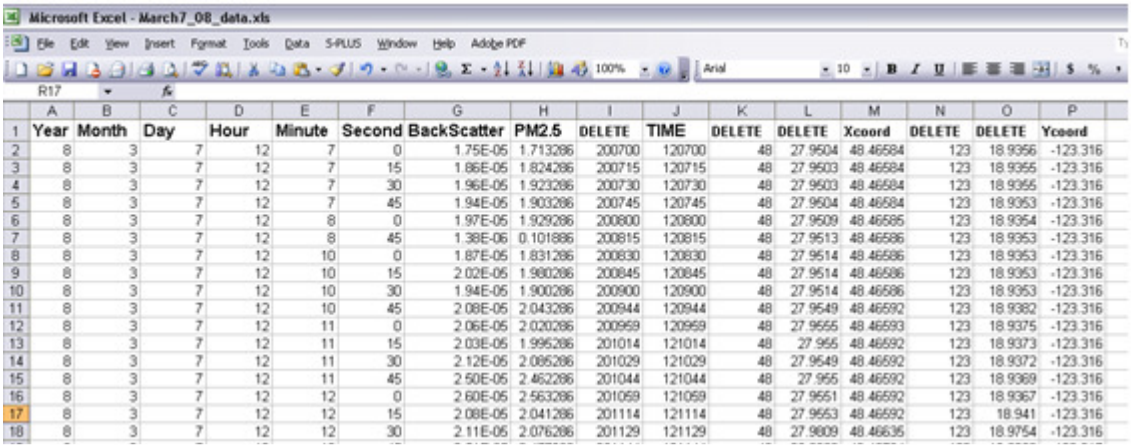
3. Select all the columns in the GPS file, and Copy



4. Go to the nephelometer file and put your cursor in the first empty cell in the first empty column – use **Paste Special**, the choose **Values** and click OK.



5. Now you should have all the records for the nephelometer and the GPS in one file – save this as Final_Data_Date.xls

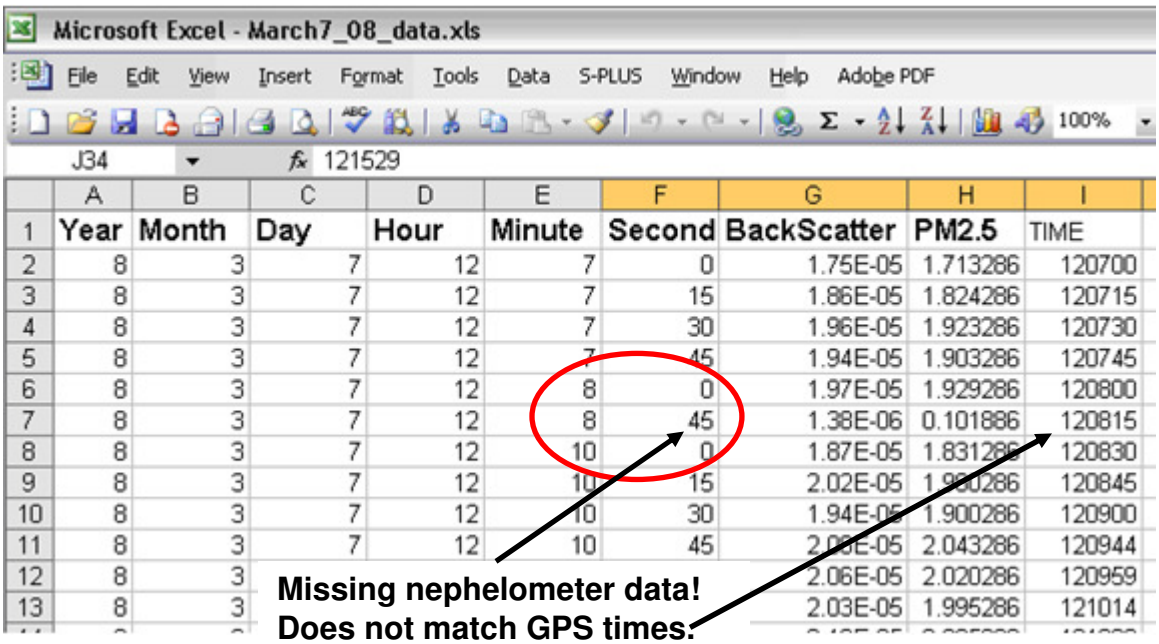


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Year	Month	Day	Hour	Minute	Second	BackScatter	PM2.5	DELETE	TIME	DELETE	DELETE	Xcoord	DELETE	DELETE	Ycoord
2	8	3	7	12	7	0	1.75E-05	1.713286	200700	120700	48	27.9504	48.46584	123	18.9356	-123.316
3	8	3	7	12	7	15	1.86E-05	1.824286	200715	120715	48	27.9503	48.46584	123	18.9355	-123.316
4	8	3	7	12	7	30	1.96E-05	1.923286	200730	120730	48	27.9503	48.46584	123	18.9355	-123.316
5	8	3	7	12	7	45	1.94E-05	1.903286	200745	120745	48	27.9504	48.46584	123	18.9353	-123.316
6	8	3	7	12	8	0	1.97E-05	1.929286	200800	120800	48	27.9509	48.46585	123	18.9354	-123.316
7	8	3	7	12	8	45	1.38E-06	0.101886	200815	120815	48	27.9513	48.46586	123	18.9353	-123.316
8	8	3	7	12	10	0	1.87E-05	1.831286	200830	120830	48	27.9514	48.46586	123	18.9353	-123.316
9	8	3	7	12	10	15	2.02E-05	1.980286	200845	120845	48	27.9514	48.46586	123	18.9353	-123.316
10	8	3	7	12	10	30	1.94E-05	1.900286	200900	120900	48	27.9514	48.46586	123	18.9353	-123.316
11	8	3	7	12	10	45	2.08E-05	2.043286	200944	120944	48	27.9549	48.46592	123	18.9382	-123.316
12	8	3	7	12	11	0	2.06E-05	2.020286	200959	120959	48	27.9555	48.46593	123	18.9375	-123.316
13	8	3	7	12	11	15	2.03E-05	1.995286	201014	121014	48	27.955	48.46592	123	18.9373	-123.316
14	8	3	7	12	11	30	2.12E-05	2.085286	201029	121029	48	27.9549	48.46592	123	18.9372	-123.316
15	8	3	7	12	11	45	2.50E-05	2.462286	201044	121044	48	27.955	48.46592	123	18.9369	-123.316
16	8	3	7	12	12	0	2.60E-05	2.563286	201059	121059	48	27.9551	48.46592	123	18.9367	-123.316
17	8	3	7	12	12	15	2.08E-05	2.041286	201114	121114	48	27.9553	48.46592	123	18.941	-123.316
18	8	3	7	12	12	30	2.11E-05	2.076286	201129	121129	48	27.9809	48.46636	123	18.9754	-123.316

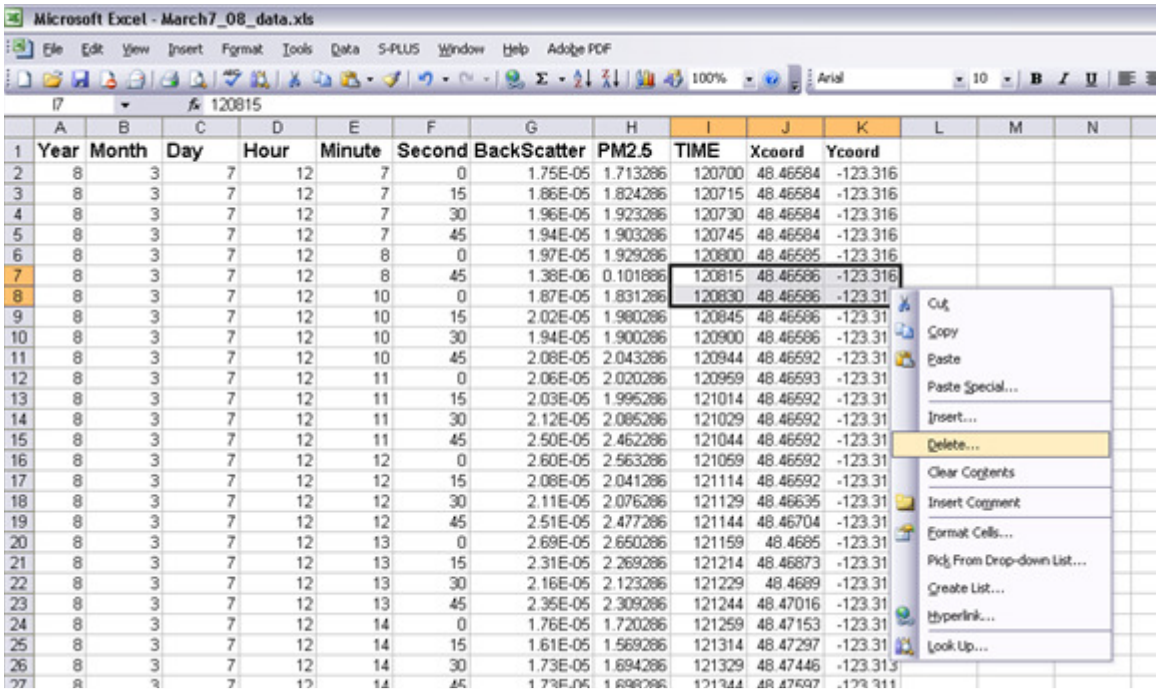
Go to the bottom of the file and check to make sure the time is still matching. Sometimes the GPS loses signal, or perhaps the nephelometer was turned on/off during the run. You'll have to adjust accordingly:

- Look for the first place where the mismatch occurs. Usually it is easiest to maximize the Excel window and spreadsheet, start at the top of the file, check the last row visible – if the nephelometer time and GPS time match, click the scroll slider on the right to advance a page, and so on. If the last row visible does not match, find the first record in that page where the mismatch starts.
- Also, if you left a blank row in the GPS file between each ACTIVE LOG file, then you should be able to easily see where mismatches might occur.

EXAMPLES:

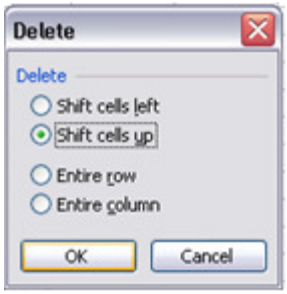

Microsoft Excel - March7_08_data.xls
File Edit View Insert Format Tools Data S-PLUS Window Help Adobe PDF
J34
121529
Missing nephelometer data!
Does not match GPS times:

	A	B	C	D	E	F	G	H	I
1	Year	Month	Day	Hour	Minute	Second	BackScatter	PM2.5	TIME
2	8	3	7	12	7	0	1.75E-05	1.713286	120700
3	8	3	7	12	7	15	1.86E-05	1.824286	120715
4	8	3	7	12	7	30	1.96E-05	1.923286	120730
5	8	3	7	12	7	45	1.94E-05	1.903286	120745
6	8	3	7	12	8	0	1.97E-05	1.929286	120800
7	8	3	7	12	8	45	1.38E-06	0.101886	120815
8	8	3	7	12	10	0	1.87E-05	1.831286	120830
9	8	3	7	12	10	15	2.02E-05	1.980286	120845
10	8	3	7	12	10	30	1.94E-05	1.900286	120900
11	8	3	7	12	10	45	2.08E-05	2.043286	120944
12	8	3					2.06E-05	2.020286	120959
13	8	3					2.03E-05	1.995286	121014

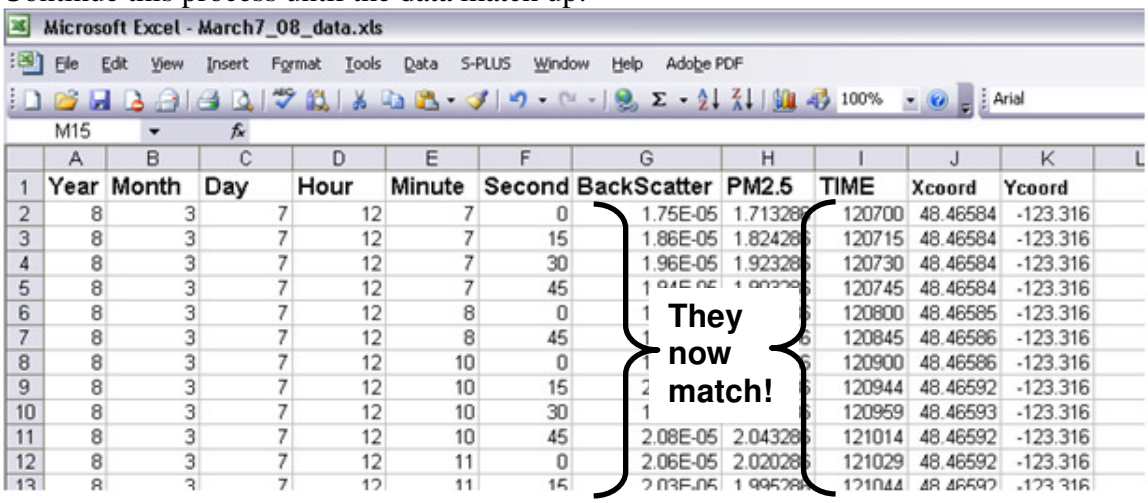


	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Year	Month	Day	Hour	Minute	Second	BackScatter	PM2.5	TIME	Xcoord	Ycoord			
2	8	3	7	12	7	0	1.75E-05	1.713286	120700	48.46584	-123.316			
3	8	3	7	12	7	15	1.86E-05	1.824286	120715	48.46584	-123.316			
4	8	3	7	12	7	30	1.96E-05	1.923286	120730	48.46584	-123.316			
5	8	3	7	12	7	45	1.94E-05	1.903286	120745	48.46584	-123.316			
6	8	3	7	12	8	0	1.97E-05	1.929286	120800	48.46585	-123.316			
7	8	3	7	12	8	45	1.38E-06	0.101886	120815	48.46586	-123.316			
8	8	3	7	12	10	0	1.87E-05	1.831286	120830	48.46586	-123.31			
9	8	3	7	12	10	15	2.02E-05	1.980286	120845	48.46586	-123.31			
10	8	3	7	12	10	30	1.94E-05	1.900286	120900	48.46586	-123.31			
11	8	3	7	12	10	45	2.08E-05	2.043286	120944	48.46592	-123.31			
12	8	3	7	12	11	0	2.06E-05	2.020286	120959	48.46593	-123.31			
13	8	3	7	12	11	15	2.03E-05	1.995286	121014	48.46592	-123.31			
14	8	3	7	12	11	30	2.12E-05	2.085286	121029	48.46592	-123.31			
15	8	3	7	12	11	45	2.50E-05	2.462286	121044	48.46592	-123.31			
16	8	3	7	12	12	0	2.60E-05	2.563286	121059	48.46592	-123.31			
17	8	3	7	12	12	15	2.08E-05	2.041286	121114	48.46592	-123.31			
18	8	3	7	12	12	30	2.11E-05	2.076286	121129	48.46635	-123.31			
19	8	3	7	12	12	45	2.51E-05	2.477286	121144	48.46704	-123.31			
20	8	3	7	12	13	0	2.69E-05	2.650286	121159	48.4685	-123.31			
21	8	3	7	12	13	15	2.31E-05	2.269286	121214	48.46873	-123.31			
22	8	3	7	12	13	30	2.16E-05	2.123286	121229	48.4689	-123.31			
23	8	3	7	12	13	45	2.35E-05	2.309286	121244	48.47016	-123.31			
24	8	3	7	12	14	0	1.76E-05	1.720286	121259	48.47153	-123.31			
25	8	3	7	12	14	15	1.61E-05	1.569286	121314	48.47297	-123.31			
26	8	3	7	12	14	30	1.73E-05	1.694286	121329	48.47446	-123.31			

In this case, delete the extra GPS data to match up the times with the nephelometer data. Select the rows you want to delete, right click **delete** and **shift cells up**:

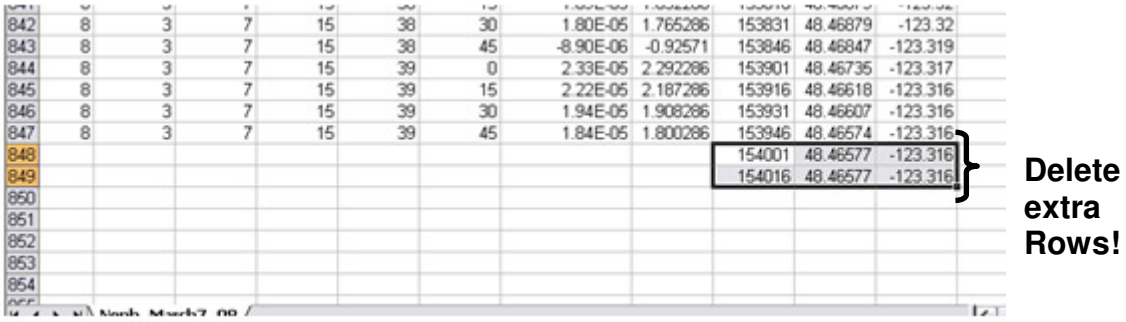


Continue this process until the data match up:


Microsoft Excel - March7_08_data.xls
File Edit View Insert Format Tools Data S-PLUS Window Help Adobe PDF
M15
They now match!

	A	B	C	D	E	F	G	H	I	J	K
1	Year	Month	Day	Hour	Minute	Second	BackScatter	PM2.5	TIME	Xcoord	Ycoord
2	8	3	7	12	7	0	1.75E-05	1.713286	120700	48.46584	-123.316
3	8	3	7	12	7	15	1.86E-05	1.824286	120715	48.46584	-123.316
4	8	3	7	12	7	30	1.96E-05	1.923286	120730	48.46584	-123.316
5	8	3	7	12	7	45	1.94E-05	1.903286	120745	48.46584	-123.316
6	8	3	7	12	8	0	1	6	120800	48.46585	-123.316
7	8	3	7	12	8	45	1	6	120845	48.46586	-123.316
8	8	3	7	12	10	0	1	6	120900	48.46586	-123.316
9	8	3	7	12	10	15	2	6	120944	48.46592	-123.316
10	8	3	7	12	10	30	1	6	120959	48.46593	-123.316
11	8	3	7	12	10	45	2.08E-05	2.043286	121014	48.46592	-123.316
12	8	3	7	12	11	0	2.06E-05	2.020286	121029	48.46592	-123.316
13	8	3	7	12	11	15	2.03E-05	1.995286	121044	48.46592	-123.316

- Finally, delete any extra rows at the bottom that do not have both nephelometer and GPS data.



842	8	3	7	15	38	30	1.80E-05	1.765286	153831	48.46879	-123.32
843	8	3	7	15	38	45	-8.90E-06	-0.92571	153846	48.46847	-123.319
844	8	3	7	15	39	0	2.33E-05	2.292286	153901	48.46735	-123.317
845	8	3	7	15	39	15	2.22E-05	2.187286	153916	48.46618	-123.316
846	8	3	7	15	39	30	1.94E-05	1.908286	153931	48.46607	-123.316
847	8	3	7	15	39	45	1.84E-05	1.800286	153946	48.46574	-123.316
848									154001	48.46577	-123.316
849									154016	48.46577	-123.316
850											
851											
852											
853											
854											

6. Do a little data quality check:

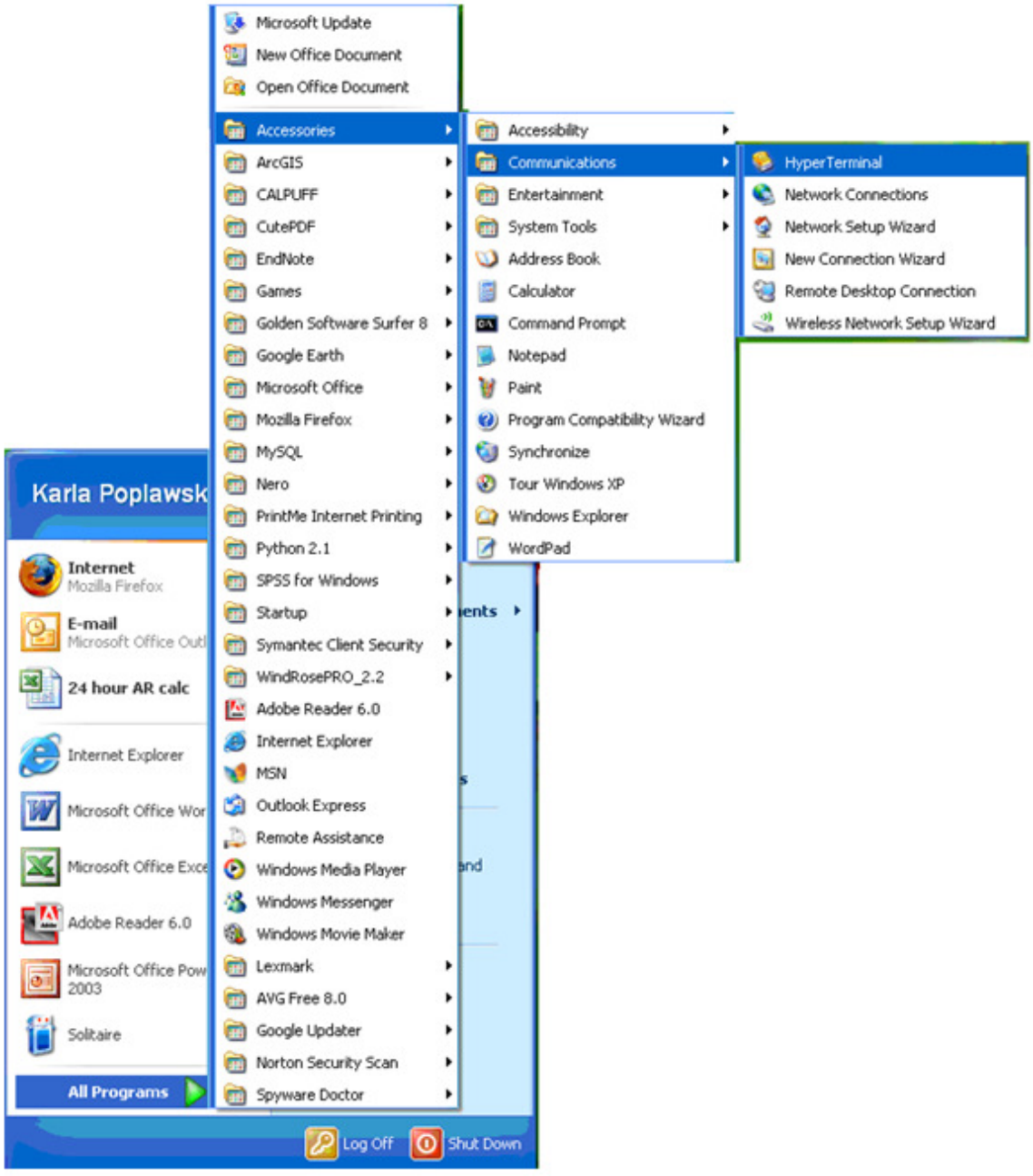
Sometimes the nephelometer will record a negative value – delete these rows as they indicate a level at or below the detection limit, or unstable readings just after turning on the equipment.

840	8	3	7	15	38	0	2.20E-05	2.159286	153801	48.46878	-123.32
841	8	3	7	15	38	15	1.89E-05	1.852286	153816	48.46879	-123.32
842	8	3	7	15	38	30	1.80E-05	1.765286	153831	48.46879	-123.32
843	8	3	7	15	38	45	-8.90E-06	-0.92571	153846	48.46847	-123.319
844	8	3	7	15	39	0	2.35E-05	2.292286	153901	48.46735	-123.317
845	8	3	7	15	39	15	2.22E-05	2.187286	153916	48.46618	-123.316
846	8	3	7	15	39	30	1.94E-05	1.908286	153931	48.46607	-123.316

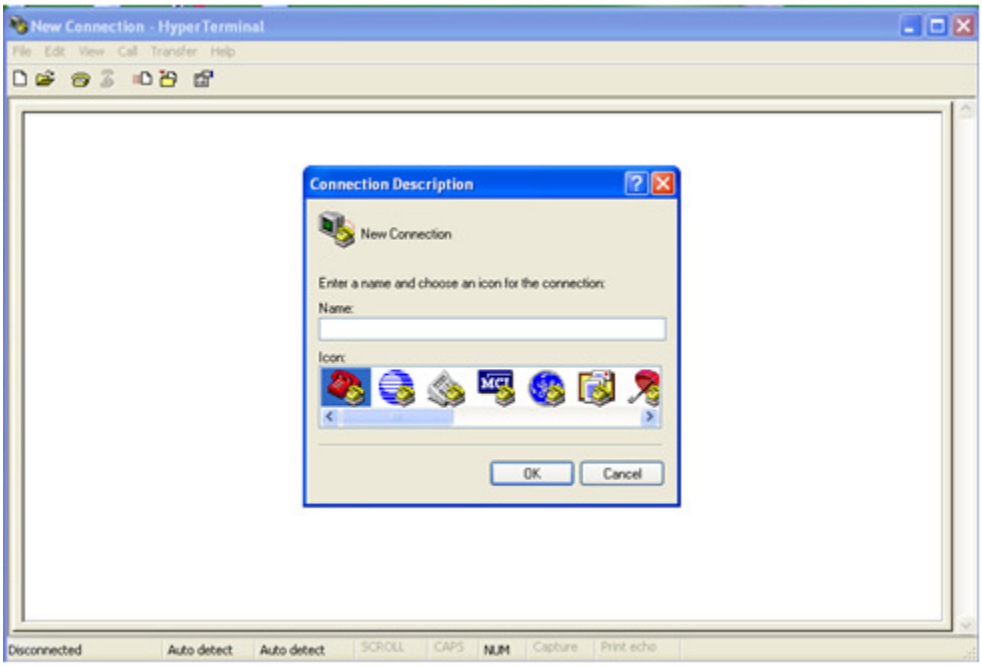
3. SAVE. This file can now be easily converted for mapping using a geographic information system.

SETTING UP THE HYPERTERMINAL CONNECTION FOR THE NEPHELOMETER ON A NEW COMPUTER

1. Install the SERIAL to USB driver from the CD in the software package.
2. From the Start Menu select All Programs > Accessories> Communications > Hyper terminal, as displayed below.

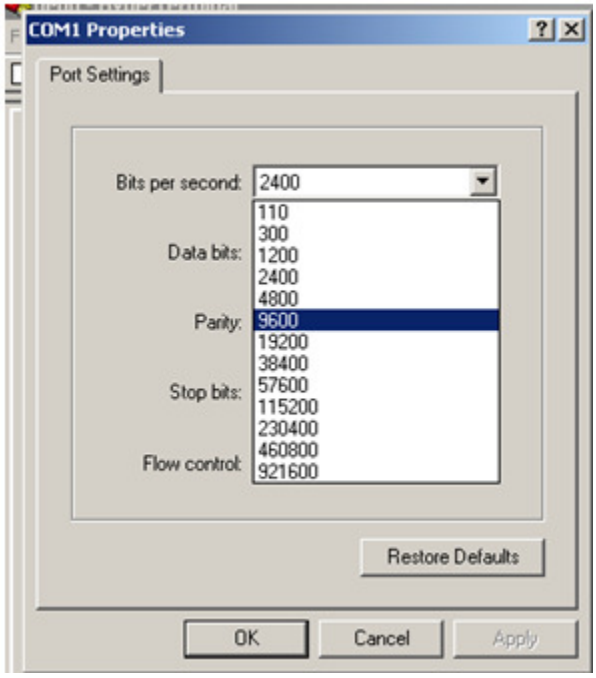


3. You will be prompted whether you would like to establish a new connection. Give the connection a name, such as “neph” and select an icon. Then click “ok”.

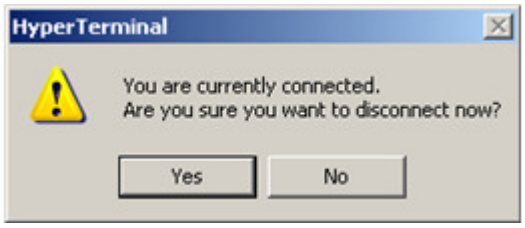


4. Next, choose the COM port which corresponds to the USB connection on your computer which you will be plugging the nephelometer into. Click “ok”.

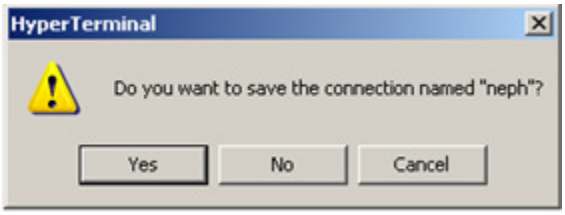
5. When asked to specify the properties about the selected COM port, choose **9600** as the appropriate Bits per second. Then click "ok".



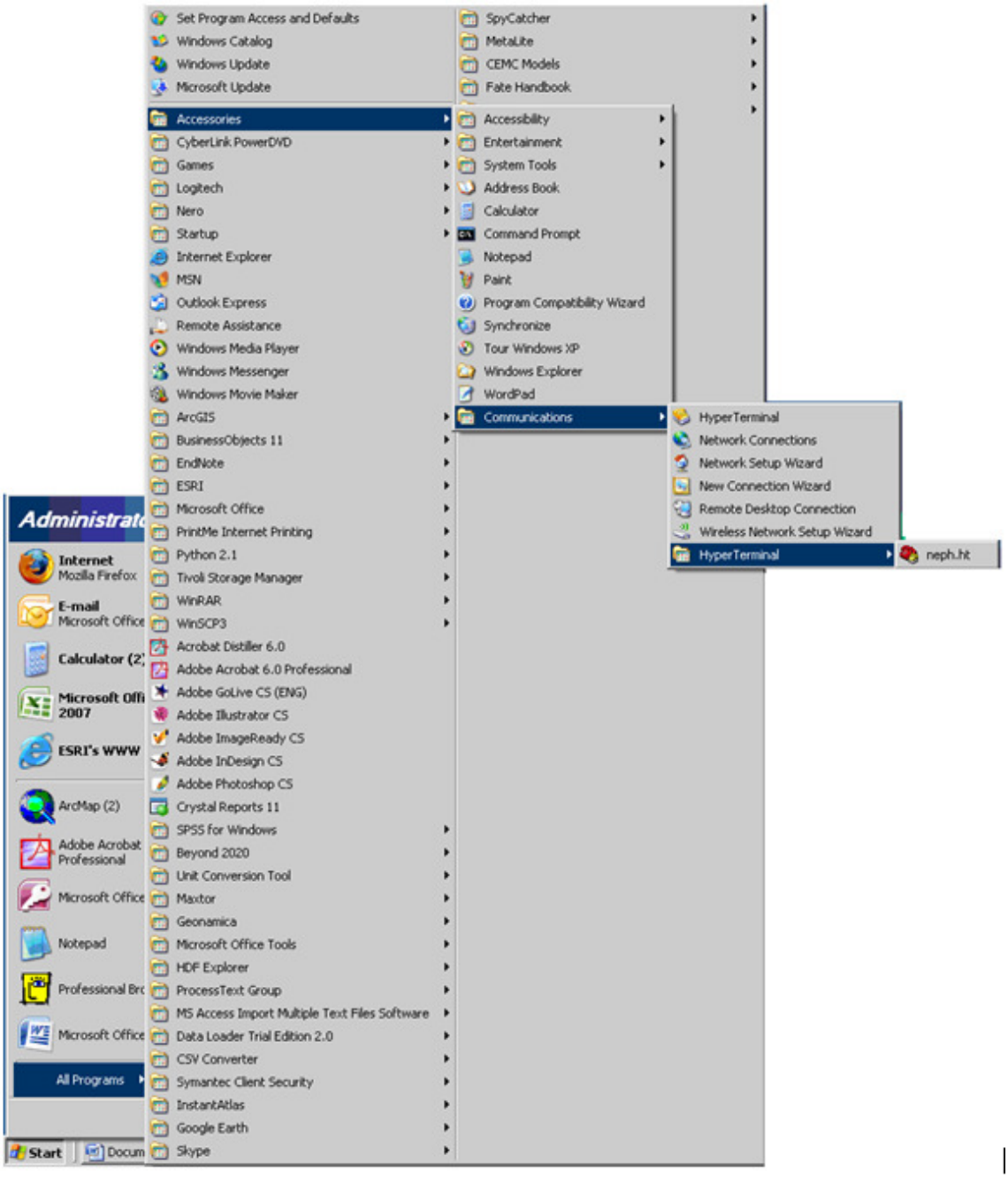
6. Exit the HyperTerminal program. You will be asked if you want to disconnect now. Select "Yes".



6. The program will ask if you want to save the "neph" connection. Click "Yes".



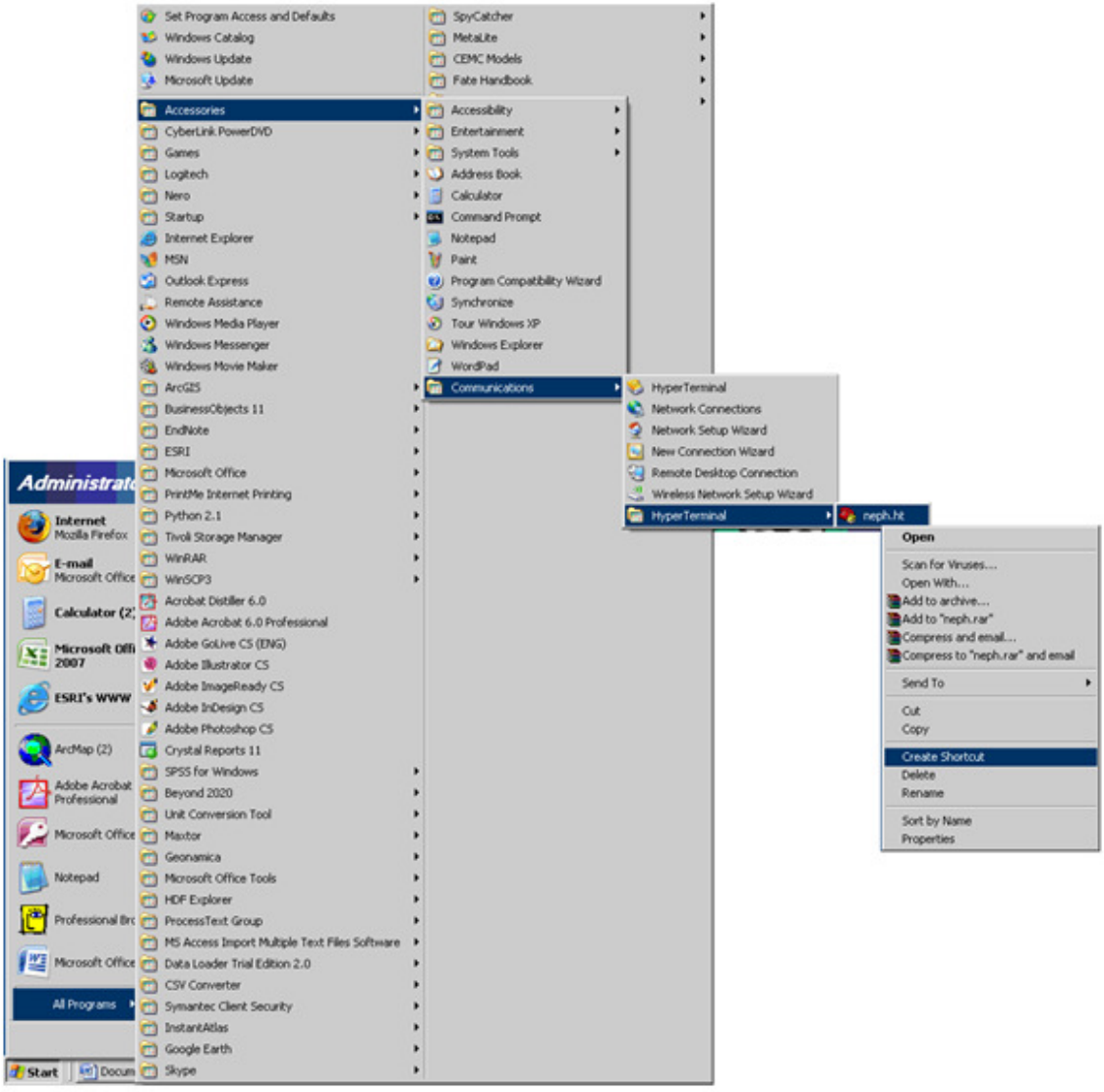
7. By choosing to save the neph connection, you will have added the "neph" icon under the Hyperterminal menu:



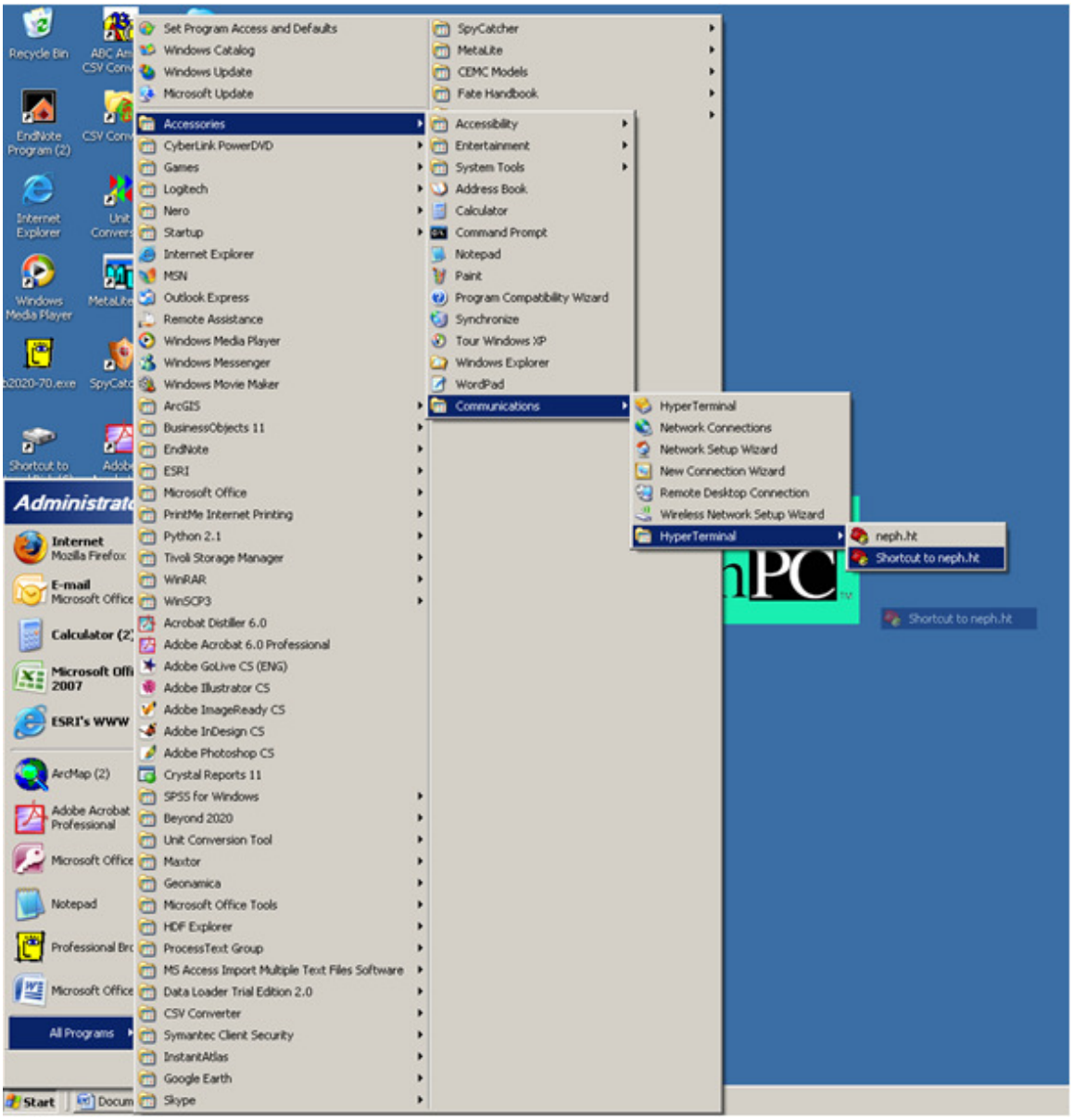
You can now access the neph connection by going to the Start Menu > All Programs > Accessories > Communications> HyperTerminal > neph.

Or you can create a shortcut for the desktop, as described next.

8. Right click on “neph” and select “Create Shortcut” from the drop-down menu that appears:



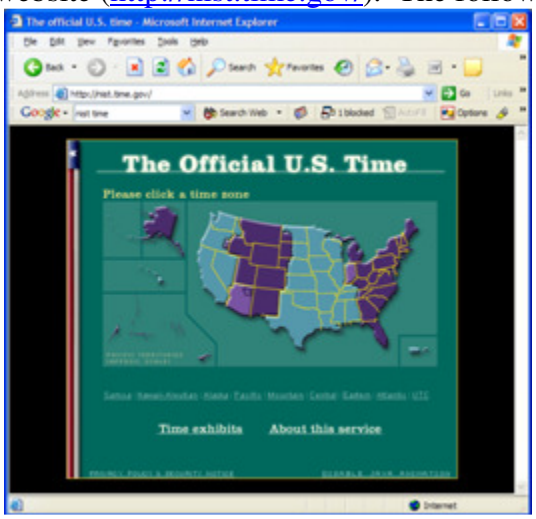
9. There will now be another icon in the HyperTerminal menu, called "Shortcut to neph". Click on the shortcut, and holding the mouse button down, drag it onto the desktop (as shown below). To access the HyperTerminal program now, all you have to do is double-click the icon on the desktop.



SYNCHRONIZING THE NEPHELOMETER AND GPS CLOCKS

The GPS unit receives very accurate times from the satellite signal, but the nephelometer's internal clock may slowly lose time. Set the nephelometer time once a month or so using the following procedure:

1. Go to the NIST website (http://nist.time.gov/). The following screen will appear



2. Click on the "Pacific" link below the map. This is Pacific Standard Time. The following screen will appear:

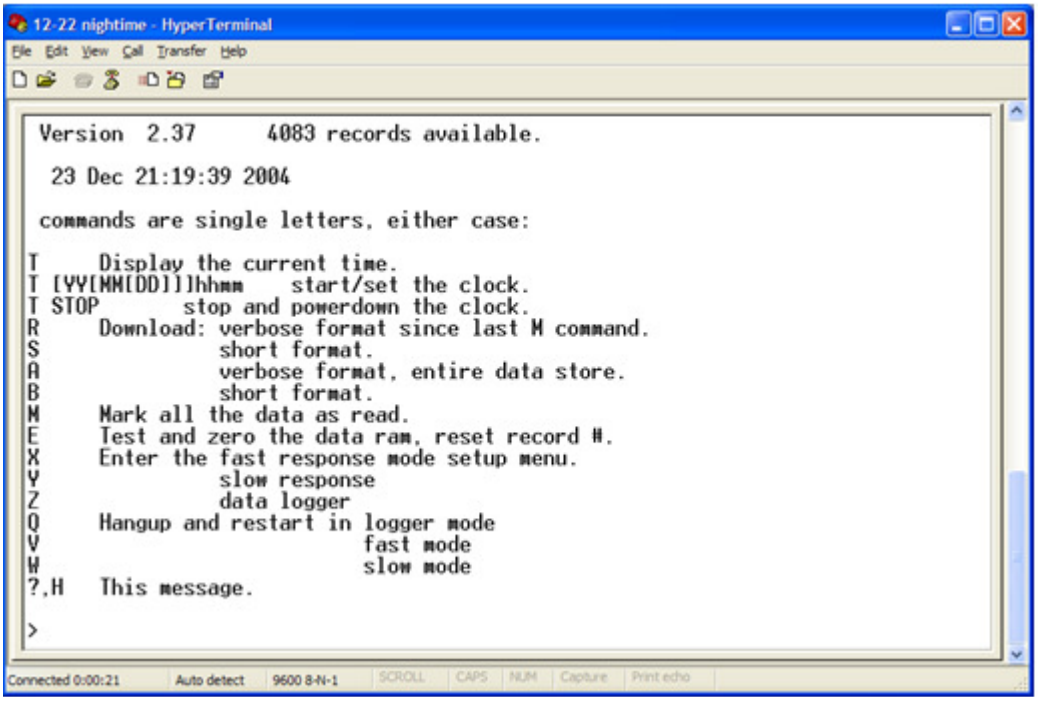
Right now, the official U.S. time is:
11:44:42
Accurate within 0.2 seconds
Change timezone
You have chosen the Pacific time zone
Coordinated Universal Time -7 hours
Daylight Saving Time
Problems? Questions?
Sun is shining in light region
It is night in dark region
THE U.S. TIME IS PROVIDED BY NIST
ABOUT THIS SITE TIME EXHIBITS

3. Connect the nephelometer to an external power source, but don't turn it on yet. Do not plug in the heater!

4. Connect the serial port between the nephelometer and a computer (use a USB adaptor if necessary.

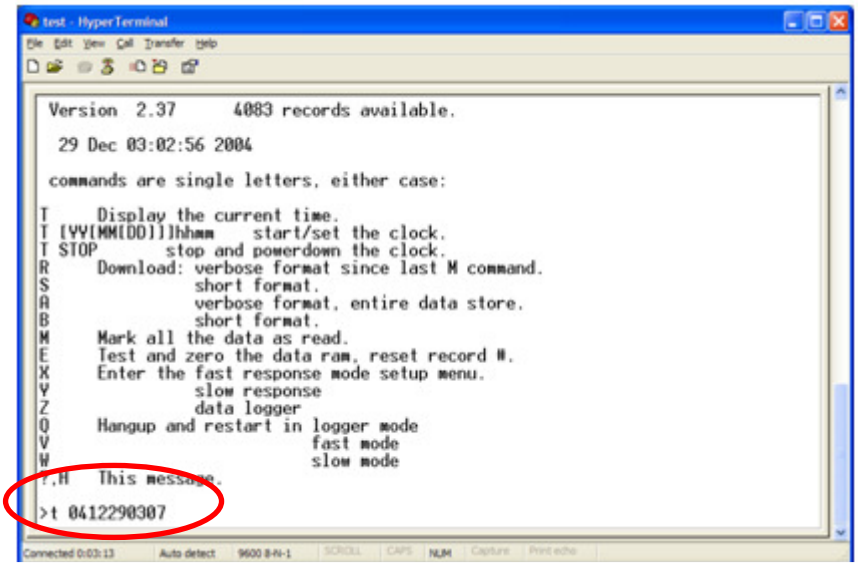
5. Open the saved nephelometer setting in Hyper Terminal (Programs/Accessories/Communications/Hyper Terminal/neph). Or double-click the Hyper Terminal icon on the desktop.

6. A blank screen will appear. Turn on the nephelometer. Data will begin scrolling down the screen. Hit "s" once and the main menu will appear, as shown:


12-22 nightime - HyperTerminal
File Edit View Call Transfer Help
Version 2.37 4083 records available.
23 Dec 21:19:39 2004
commands are single letters, either case:
T Display the current time.
T [YY[MM[DD]]]hhmm start/set the clock.
T STOP stop and powerdown the clock.
R Download: verbose format since last M command.
S short format.
A verbose format, entire data store.
B short format.
M Mark all the data as read.
E Test and zero the data ram, reset record #.
X Enter the fast response mode setup menu.
Y slow response
Z data logger
Q Hangup and restart in logger mode
V fast mode
W slow mode
?,H This message.
>
Connected 0:00:21
Auto detect
9600 8-N-1

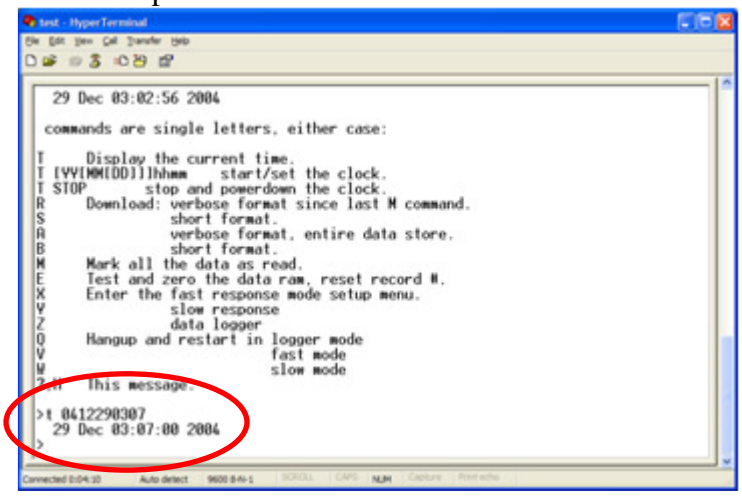
7. Arrange your computer screen so that both the UTC website is visible and the Hyper Terminal Screen is active and visible. The UTC time is shown to the closest second, whereas the nephelometer clock is set to the closest minute (although it displays seconds on the screen and in the logged file).

8. To set the nephelometer clock, on the Hyper Terminal screen type "T YYMMDDhhmm". In the example below, if you want to set the clock to 3:07 AM on Dec 29, 2004 you type "T 0412290307".


test - HyperTerminal
Version 2.37 4083 records available.
29 Dec 03:02:56 2004
commands are single letters, either case:
T Display the current time.
T [YY[MM[DD]]]hhmm start/set the clock.
T STOP stop and powerdown the clock.
R Download: verbose format since last M command.
S short format.
A verbose format, entire data store.
B short format.
M Mark all the data as read.
E Test and zero the data ram, reset record #.
X Enter the fast response mode setup menu.
V slow response
Z data logger
Q Hangup and restart in logger mode
V fast mode
W slow mode
?,H This message.
>t 0412290307

9. Hit return at the instant that the UTC time reaches the appropriate minute.

10. The current nephelometer time will be shown on the screen at that instant, as shown in the example below:


test - HyperTerminal
29 Dec 03:02:56 2004
commands are single letters, either case:
T Display the current time.
T [YY[MM[DD]]]hhmm start/set the clock.
T STOP stop and powerdown the clock.
R Download: verbose format since last M command.
S short format.
A verbose format, entire data store.
B short format.
M Mark all the data as read.
E Test and zero the data ram, reset record #.
X Enter the fast response mode setup menu.
V slow response
Z data logger
Q Hangup and restart in logger mode
V fast mode
W slow mode
?,H This message.
>t 0412290307
29 Dec 03:07:00 2004
>

11. Type "Q" and then hit "enter". The nephelometer will now go into data-logging mode again. You should hear it ticking. You can now turn the nephelometer OFF. When it is turned on again it will automatically begin logging data.

12. Close the Hyper Terminal program. At the prompt, you can choose to save or not save the session file. You do not need to save.

When you turn the nephelometer back on again, the nephelometer display will show the current time (as GMT) and the datalogger will begin logging with this time.

CHANGING THE AVERAGING TIME AND FLASH RATE

It may be desirable on occasion to change the averaging time period for stored averages. For instance, an averaging time of 15 seconds, 5 minutes, or 15 minutes might be more suitable for particular applications than others. If wishing to change the averaging time, please refer to pages 18-19 of the official M903 Nephelometer Operation Procedures manual. The following steps provided below offer a summary of how to change the nephelometer settings for different averaging periods:

1. Connect the nephelometer to an external power source (do not turn on). Do not plug in the heater!
2. Connect the download cable to the USB port.
3. Open the saved nephelometer setting in the Hyper Terminal program (Programs/Accessories/Communications/Hyper Terminal/neph) or double click the Hyper Terminal icon on the desktop.
4. A blank screen will appear. Now turn on the nephelometer. Data will begin scrolling down the screen. Hit the "s" key once and the main menu will appear.
5. Type in "z" and hit "enter" to enter the *data logger* mode.
6. To change a value, type the command letter, then a space and then the new value and hit "enter". For example, to change the E parameter to 25 and the H parameter to 15 type:
   E 25 H 15 and hit "enter"
7. Hit "enter" again to return to the main menu.
8. Type "Q" and then hit "enter". The nephelometer will now go into data-logging mode again. You should hear it ticking. You can now turn the nephelometer OFF. When it is turned on again it will automatically begin logging data.
9. Close the Hyper Terminal program. At the prompt, you can choose to save or not save the session file. You do not need to save.

The following table represents the settings necessary for a variety of different averaging times:

Item	15 sec.	1 min.	5 min.	10 min.	15 min.
A	2	2	2	2	2
B	2	2	2	2	2
C	6	6	6	6	6
D	6	6	6	6	6
E	25	50	50	100	100
F	30	35	35	35	35
G	10	10	10	10	10
H	15	60	133	133	143